THE BULLETIN

OF THE

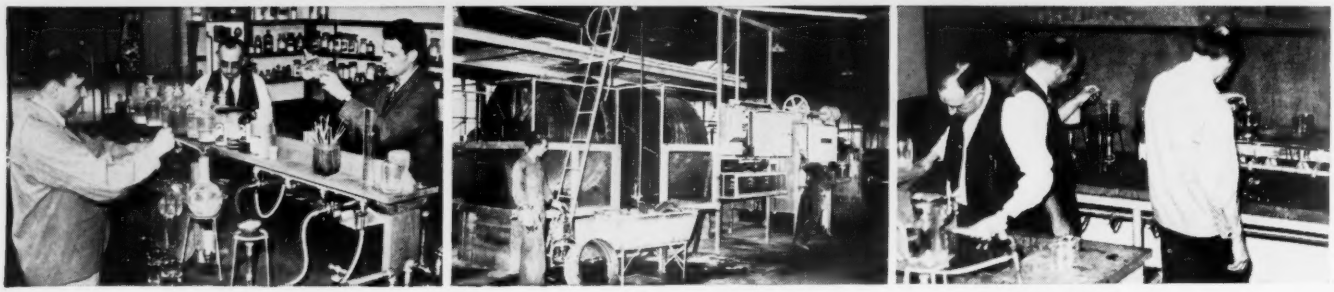
AMERICAN CERAMIC SOCIETY

Volume 20 JUNE, 1941 Number 6

SAMUEL P. HARBISON

For story see page 210

BRAINS AT WORK



The scientific eye sparkles with total appreciation at the completeness of the modern equipment, and the variety of materials and sensitive instruments in our glass and ceramics laboratories out in Washington, Pa. But of greater significance to our many customers are the keen-minded technologists whose scientific knowledge and practical field experience guide the way to easier, faster, more economical production with Drakenfeld colors and chemicals.

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THE BULLETIN OF THE AMERICAN CERAMIC SOCIETY

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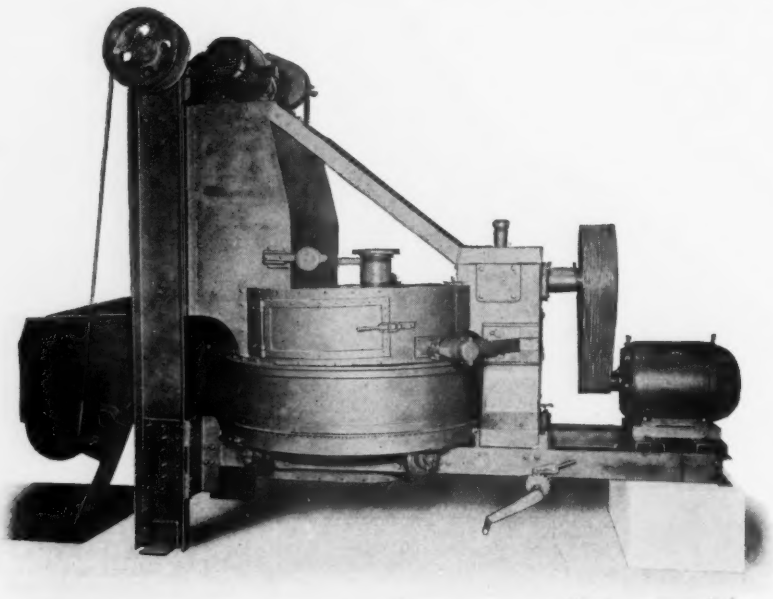

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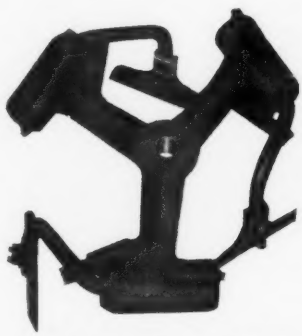

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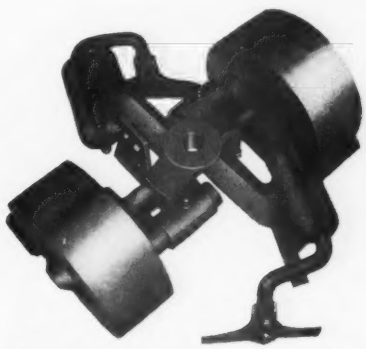

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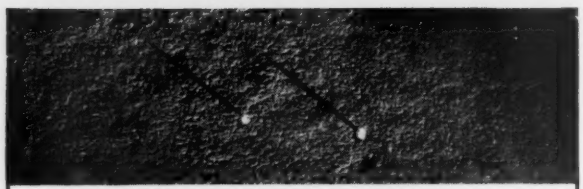

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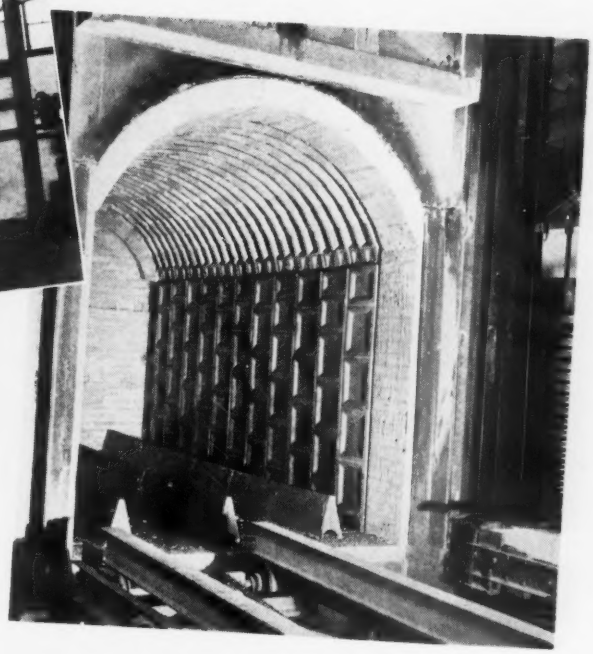

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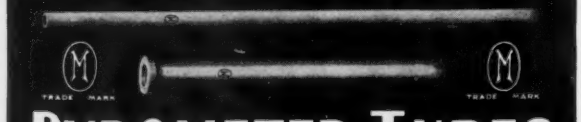

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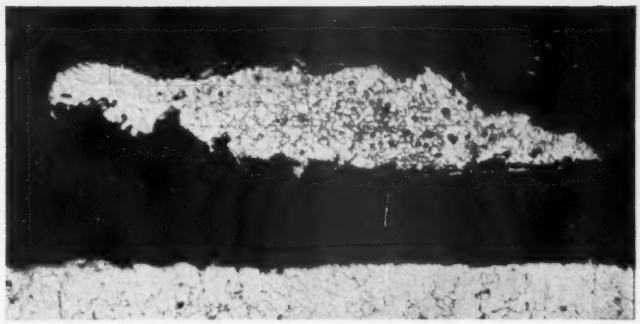
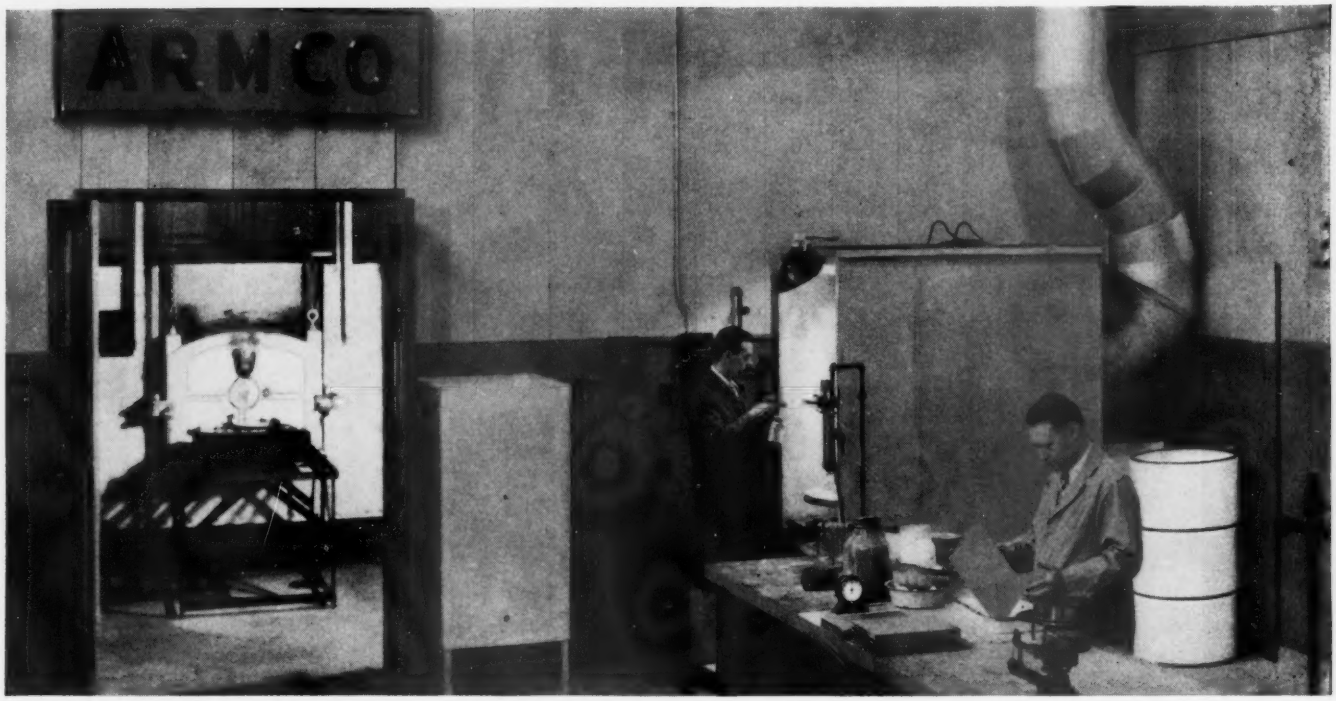


• The most important clue to the mystery is shown in this photomicrograph, which magnified a cross-section 500 times. The white bottom is the base metal. The dark top is the porcelain enamel ground coat. In it you see the light-colored "island"– the pesky little particle that caused all the trouble.



• A view in the ARMCO Enameling Laboratory. The metallurgist at the table is dipping a piece of experimental porcelain enameling iron in a test batch of porcelain enamel. His assistant is at a spray booth. An experimental furnace shows through the doorway. Here enameling processes are tested – under scientific control.

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These pictures showed high-carbon metallic particles buried in the ground coat. During firing, they caused the enamel to crack away and expose the ground coat.

With this clue, the Armco man went back and found the particles were being thrown off from a worn steel shaft in the roto-spray equipment. They were so small and light that the magnetic separator would not pull them out of the enamel.

"Let's install a non-ferrous shaft," he suggested. So time, labor and materials were saved.

If you have a perplexing enameling problem, the Armco Enameling Service Man and the Armco Enameling Laboratory can probably help you. Write to The American Rolling Mill Co., 1020 Curtis Street, Middletown, O.

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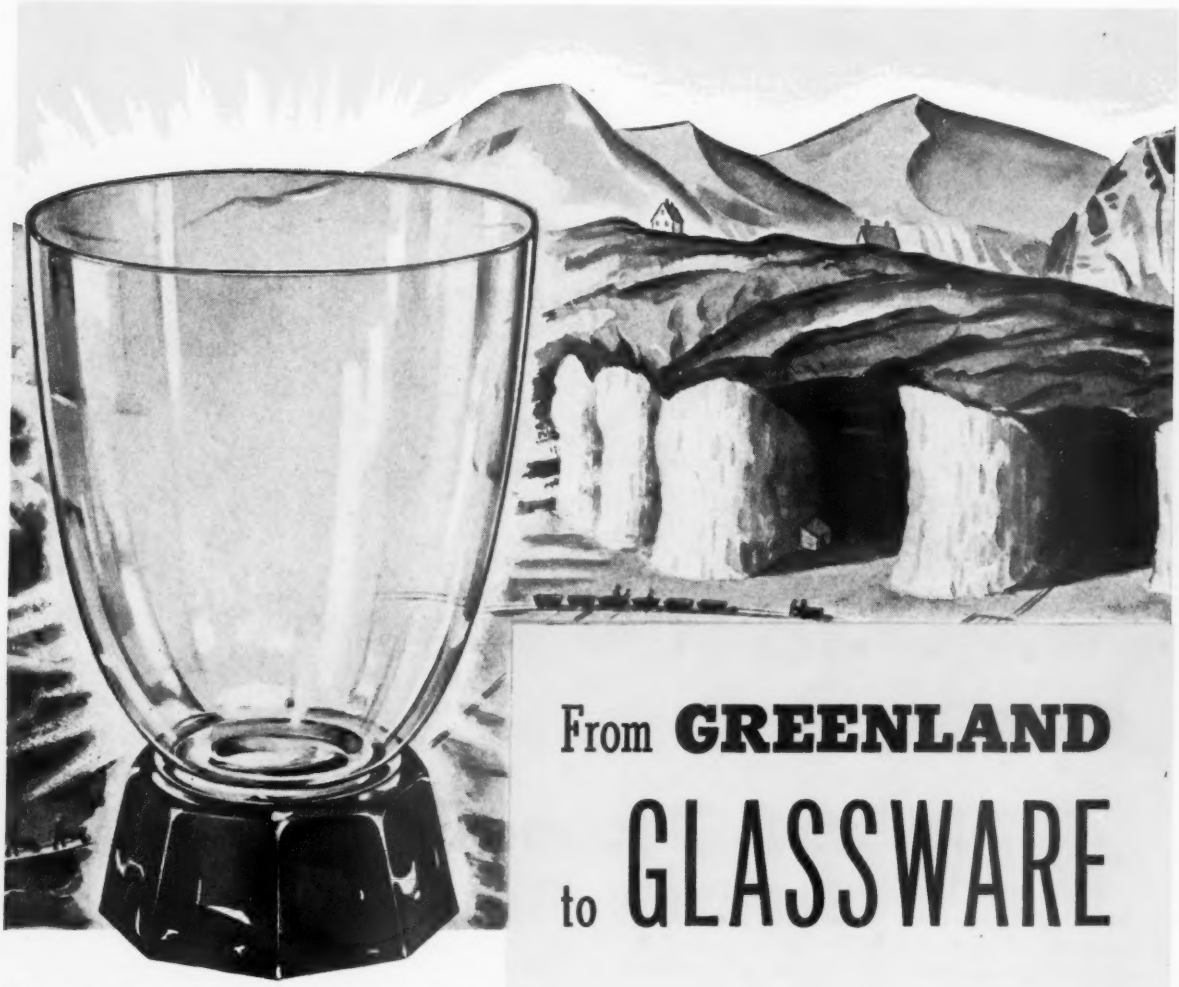

This illustration shows a view of cryolite mine in Greenland.

From **GREENLAND** to GLASSWARE

THAT isn't much of a transition when the connecting link is Kryolith, the natural cryolite found in commercial quantities only in southwest Greenland.

For in the glass, ceramic and enamel industries, Kryolith is well known as an ideal flux. Manufacturers of glassware, for instance, report that Kryolith helps to reduce the tendency toward cords and is useful in dissolving many of the coloring oxides . . . improving the clarity, color and lustre of finished products.

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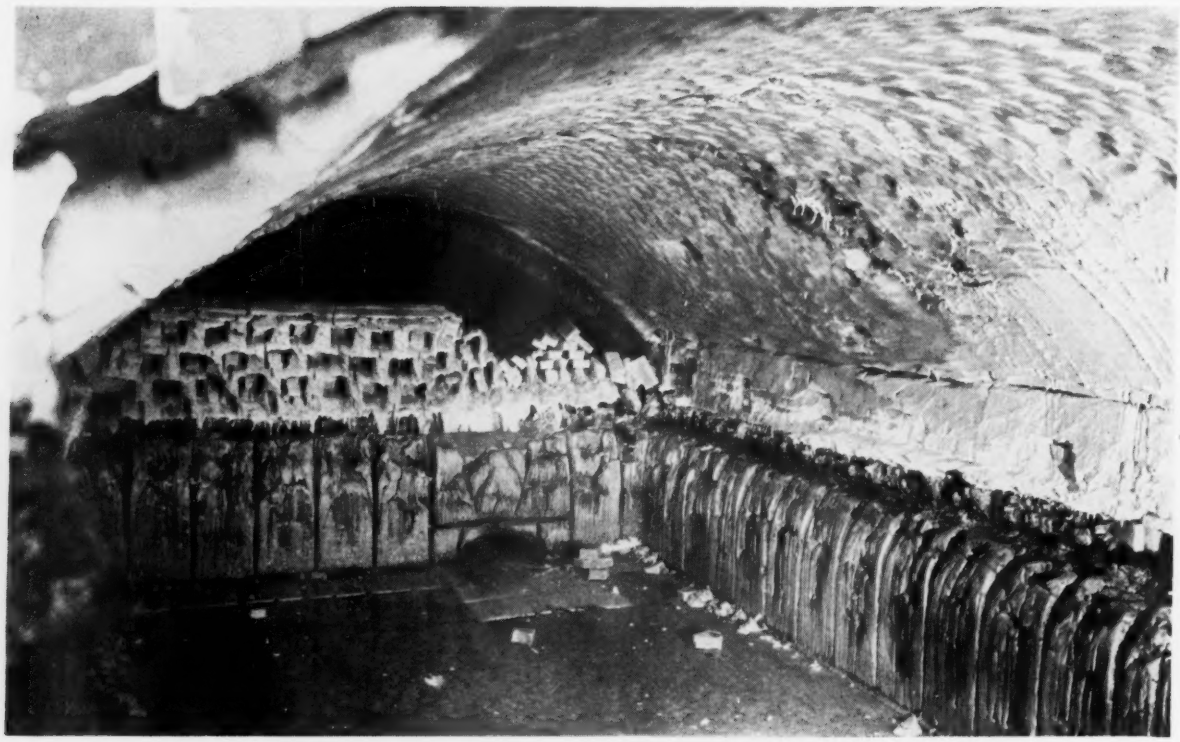

Corhart* Electrocast Helps Set New Record!

IN TIMES like these, when every productive facility is being pushed to capacity, it is only to be expected that new production records will constantly be set in the glass industry, and that old "highs" will come to be regarded as merely routine accomplishments. . . . A few years ago, for instance, a production of 60-tons-produced-per-square-foot-of-melting-area was considered spectacular. Yet here are the figures for a Standard Electrocast furnace, melting flint bottle glass, which was recently shut down after setting a record of 196.1 tons-per-square-foot-of-melting-area!

Fire placed in tank	*January 20, 1938*
Closed for repairs	*December 24, 1940*
Melting end	*14' x 27'—378 sq. ft.*
Total, continuous lapsed life	*1,069 days*
Operating life	*1,006 days*
Total tons glass pulled	*74,137*
Average pull per operating day	*73.69 tons*
Sq. ft. melting area per ton per operating day	*5.13*
Tons produced per sq. ft. of melting area	*196.1*

Corhart is glad that Standard Electrocast has had a part in setting new production records during the past decade. But we of Corhart always have known, and always will continue in the knowledge, that high production records are at least as much a result of better furnace design and better furnace operation, as they are of better refractories. . . . Through continuing research and with the continuing cooperation of the glass industry, we confidently expect to participate in the new production records of the *next* decade. . . .

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THE BULLETIN
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A Monthly Publication Devoted to Proceedings of The Society and Promotion of Cooperative Research of Technical, Scientific, and Art Questions

Volume 20 JUNE, 1941 Number 6

PAPERS

NEW METHODS OF CLEANING GLASS SANDS*

By John Dasher and O. C. Ralston†

Abstract

The various forms of iron-bearing impurities in glass sands are described, and methods for the removal of each type of impurity are discussed, with emphasis on the attrition scrubber, froth flotation, and agglomeration. The equipment and operating items that make up costs are listed, and detailed results of various treatments on different sands are included.

I. Introduction

(1) Impurities

A glass sand, to a layman, is a pure silica sand, but the glassmaker and the miner of glass sands know better. No glass sand is pure, and no one has ever prepared a pure silica sand. Selected clean, quartz grains analyze about 0.01% of Fe_2O_3. This amount of iron probably is in solid solution and cannot be removed without dissolving the quartz. There are innumerable sand banks, but only a few approach the degree of purity acceptable to the glassmakers. Many of the sands that are not acceptable now were once sufficently pure, but they have since become stained or otherwise contaminated. Such sands may be beneficiated by mechanical or chemical means to remove the impurities. Some of these various methods of beneficiation that are not too expensive are in commercial use.

A sand bank is an accumulation of the minerals that are most resistant to weathering from the rocks that once formed hills and mountains. Quartz is only one of those resistant minerals. Some sands are too young to have had all of the feldspar grains weathered or worn away. Hard, heavy minerals, moreover, such as zircon, rutile, and garnet, almost invariably are mixed with the silica grains. Water or wind sorting sometimes has removed all but a trace of these impurities. The action of these mediums tends to separate material of different specific gravity or of different sizes and shapes.

The first problem of the producer of glass sand is to learn the petrography of the sand bank and to identify every mineral and stain that is present in quantities sufficient to endanger the purity or the acceptability of the product. The second problem is to organize the least expensive and most efficient beneficiation methods to remove these impurities.

Silica sand is the principal ingredient in glassmaking and iron is its most detrimental impurity. Iron compounds occur in silica sand in many forms. The types of these iron impurities may be simplified for discussion into the following classes: discrete grains (specks) of iron minerals, minerals containing iron, or minerals with iron compounds in solid solution and stains containing or consisting of iron oxide. Iron may be present as discrete grains of hematite, magnetite, limonite, or pyrite; as iron-containing minerals such as hornblende, biotite, ilmenite, and garnet; or it may be present in solid solution in some such impurity as muscovite, sericite, rutile, and zircon. Iron may be present as a stain on the quartz grain or as part of a stain (e.g., the grains are coated with a ferruginous clay) or as a stain on or in some impurity such as the cracked and weathered feldspar of some western sands. These grains may be put in either class; either their stain or the feldspar grains could be removed.

Iron may be present in any, several, or all of the foregoing forms. The treatment required depends on the amount of each type of impurity present.

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† Respectively, assistant chemical engineer, Bureau of Mines, Eastern Experiment Station, College Park, Md., and chief engineer, Nonmetals Division, Bureau of Mines.

(2) Removal of Specks

Several processes have been available for the removal of discrete grains containing iron compounds. Magnetic separation will remove iron-bearing grains. High-intensity magnetic separators will remove grains if they contain as much as 1.5% of Fe_2O_3. Classification and tabling or tabling alone have been used on several sands to reject the high-density particles which include many of the iron minerals mentioned before and various other sulfides, oxides, and silicates of aluminum, lead, copper, zinc, nickel, chromium, manganese, and other metals.

Froth flotation with soap-type reagents (anionic collectors) will remove the heavy, magnetic, iron-bearing impurities, although for this purpose flotation usually is less efficient than tabling in the laboratory. Commercial flotation cells, however, may be as efficient or more so than tabling. The relatively new cationic collectors will effect complete and efficient removal of feldspar, mica, and sericite but tabling and magnetic separation are not satisfactory for this purpose.

Acid leaching will also remove some of the speck material.

(3) Removal of Stains

Stains of iron oxide or ferruginous clay may be removed in some cases from the grains by mild and gentle washing. Acid leaching is used (1) in this country,[1] with sulfuric acid; (2) in England,[2] with various other chemicals, such as sodium acid oxalate-ferrous sulfate; and (3) on the Continent, with ferrous sulfate-sulfuric acid. All of these acids are quite effective for some stains.

Moist ferruginous clay stains are easily washed away, and hematite stains are removed quite thoroughly by leaching. Nature, however, has indurated some ferruginous clay stains into a tough, adherent, compact coating. These stains do not wash off easily and they are only partly removed by leaching.

Modern froth-flotation cells provide a more severe agitation than that of the paddle, screw, or rake washers now used at most sand plants. When specks and stains in sands must both be removed to obtain the desired results, flotation of the iron minerals will also accomplish the necessary removal of the stains in the same operation if they are not too tough. Because flotation is a surface phenomenon, the quartz grains with heavy hematite stains behave as though they were all hematite and they will float with the iron minerals.

For tougher stains, the attrition scrubber may be used. It has been described and a few results were given,[3] but it has been reconstructed, modified, and tested on a large number of sands. This scrubber provides the severity of action necessary to rub off some of these tough clay stains.

(4) Processes, Machines, and Costs

Magnetic separators are rather expensive but they have a long life for high-intensity separations. Less-expensive, lower-powered separators, however, may sometimes be satisfactory. Various estimates of 15 to 50 cents per ton have been made for their operating costs.

Classification and tabling are performed with spigot or rake-type classifiers and settling cones and with the Wilfley, Deister, or other types of shaking tables. The cost of the equipment is rather high, but operating costs are low, with estimates of 5 to 15 cents per ton for classification and 10 to 40 cents per ton for tabling.

Leaching with sulfuric acid requires acidproof equipment, but tanks of wood and rubber- or lead-covered steel are satisfactory and not too expensive; the cost of operation and of the acid, however, is about 75 cents per ton.

Flotation with deep, large cells has a lower operating cost than ordinary ore flotation, but it may be as much as 50 cents per ton; the cost of the equipment is moderate. The reagents required for the separation of feldspar are expensive, but the cost of reagents to float other minerals is rather moderate; this cost in some cases ranges from 10 cents for soap flotation to 75 cents per ton for feldspar flotation; the smaller the scale of operations, however, the higher the cost.

The attrition scrubber is not yet in commercial operation, and the cost of its development will fall on those who lead the way. If all parts are rubber-covered to prevent abrasion, the wear should not be excessive. The operating and original costs will be low for a definite capacity, and power measurements on the laboratory machine indicate that from $2^1/_2$ to 10 h.p.-hr. per ton are adequate for most of the samples to be tested.

A small continuous scrubber* has been constructed, which has a 12- by 12-in. iron rotor; it operates in a wood barrel with wood stator blades and draws 3.4 h.p. This rotor is being used to remove iron stain and other weathering products from the surface of spodumene, which is being concentrated by flotation on a small scale to obtain "lithospar."[4]

The Silica Company of California, at Brentwood, has installed a commercial scrubber, but unusual weather conditions and other interruptions have not permitted it to be tested.[5]

Subcommercial scrubbers to test this new method of beneficiation on sands and other nonmetallics are being constructed or designed.

II. Attrition Scrubber

The attrition scrubber (Figs. 1 and 2) is a laboratory machine that has been developed at the Eastern

[1] "Brentwood Sand," *Eng. Mining Jour.*, **138** [12] 29–31 (1937).

[2] F. W. Adams, "New Process for Removal of Iron Oxide from Silica Sands," *Jour. Soc. Glass Tech.*, **19**, 118–24 (1935); *Ceram. Abs.*, **16** [7] 220 (1937); "Purification of Glassmaking Sands on a Commercial Scale," *Jour. Soc. Glass Tech.*, **21** [87] 409–14 (1937); *Ceram. Abs.*, **17** [9] 304 (1938).

[3] J. E. Norman and O. C. Ralston, "Conditioning Surfaces for Froth Flotation," *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 1074; *Mining Tech.* (May, 1939).

* Constructed by the United Feldspar Minerals Co., Spruce Pine, N. C.

[4] B. C. Burgess, private communication; see also J. E. Norman and E. W. Gieseke, "Beneficiation of Spodumene Rock by Froth Flotation," *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 1161; *Mining Tech.*, **4** [2] 9 pp. (March, 1940); *Ceram. Abs.*, **19** [8] 198 (1940).

[5] K. G. Schwegler, private communication.

Experiment Station of the Bureau of Mines. It is designed to provide a severity of agitation sufficient to rub off the coating of the mineral grains without breaking the grains. It is designed to produce maximum turbulence in a water suspension or pulp so that the grains collide and rub against each other. It is an agitator with a rotor and stator which almost fill the space where the pulp is confined. The clearance between the rotor and stator is small, but it is several times the diameter of the largest grain so that the scrubber will not grind. As rubber linings prevent sand grains from rubbing against any hard surface except that of other grains, the machine is designed for mutual- or self-attrition.

The four sets of rotors and stators, which are described in Table I and shown in Fig. 3, have been constructed and tested since Norman and Ralston published their results.[3] Tables II to VIII and Figs. 4 and 5 show the results of these tests. The container carrying the stator has been mounted on a pivot to permit the measurement of torque. This dynamometer permits the accurate calculation of power input and the comparison of different rotors and stators. The time of treatment is regulated to give the desired work, usually 10 h.p.-hr. per ton† for test purposes.

The sands used had a heavy tough stain so that enough difference in iron content could be obtained to permit differentiation between two similar treatments. The iron analyses shown in Tables II to VIII are not typical of scrubbed products because the sands were specially selected for their heavy, tough stain. The test samples were dried, mixed, and sampled. This small sample was stage-ground in an agate mortar;

† The calculations are made from the following formulas:

$$\text{H.p. input} = \frac{\text{pull (gm.) on 4-in. arm} \times \text{r.p.m.}}{7{,}140{,}000}$$

$$\text{H.p.-hr./T.} = \frac{\text{input (h.p.)} \times \text{treatment (min.)} \times 15{,}100}{\text{sample (gm.)}}$$

or

$$\text{Treatment (min.)} = \frac{\text{(h.p.-hr./T.)} \times \text{sample (gm.)}}{\text{input (h.p.)} \times 15{,}100}.$$

These formulas may be reduced to graphs or nomographs for convenience.

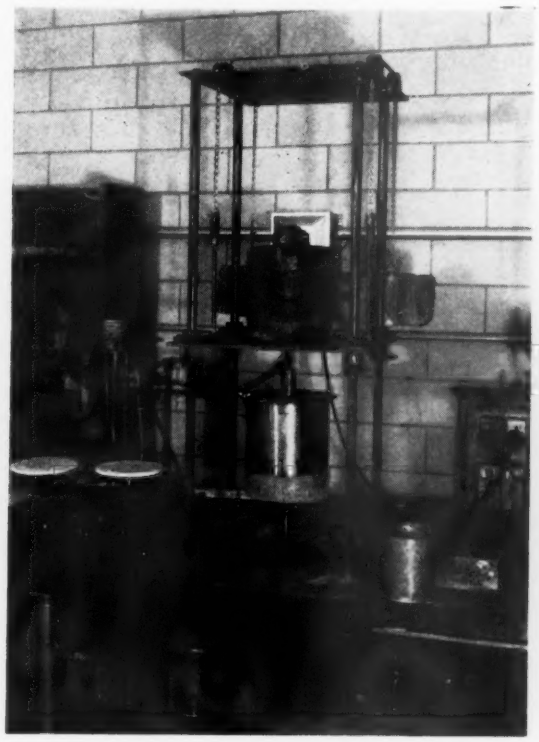

FIG. 1.—Attrition scrubber with dynamometer (constant speed drive).

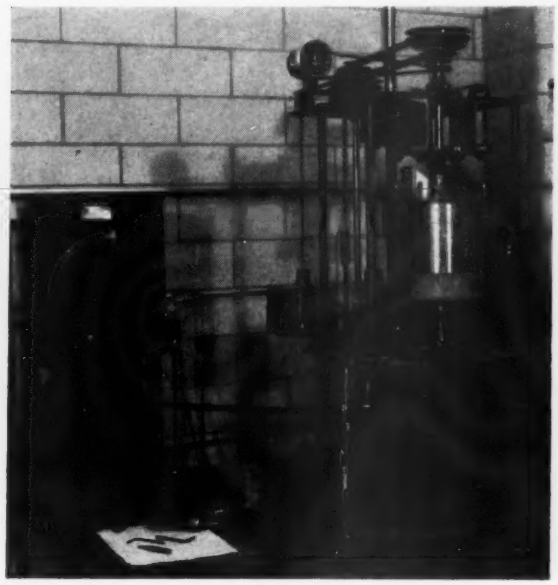

FIG. 2.—Attrition scrubber with variable speed drive and larger motor.

TABLE I

DESCRIPTION OF ROTORS AND STATORS FOR LABORATORY SCRUBBER

No.	Design inspiration	Diam. of rotor (in.)	Peripheral speed (ft./min.) r.p.m.	Pulp capacity (liter)	Max. speed (ft./min.)	Max. input (h.p.)	Reason for limit	Silica sand (Fe_2O_3 %)
1	Old scrubber	$3^{13}/_{16}$	1.0	0.5–1.3	1800	0.15	Vibration	0.048
2	Dorr agitator	5	1.31	0.5–2.5	3500	0.90	Drive (max. speed)	0.045
3	Fagergren float cell	$3^1/_2$	0.92	2.3	2500	0.40	" (" ")	0.050
4	Denver float cell	6	1.56	1.9	1200	0.40	" (" power*)	0.040

All fit into a stainless-steel beaker, $6^3/_4$ in. in diameter and $7^1/_2$ in. high.

* Although the torque is high, the belt will not transmit more than 0.40 h.p. because of the slow speed (750 r.p.m.).

one half was rejected after each stage until about 1 gram of very fine powder remained, which was analyzed spectrographically for iron oxide and, occasionally, for alumina or lime. A qualitative determination of the other metals present was often made. The analyses were checked from time to time by including a known standard among the unknowns and by commercial chemical analyses of the samples. The agreement at first was only fair for values of less than 0.04% of Fe_2O_3, but adjustment of spectrographic technique permitted an excellent check to be obtained.

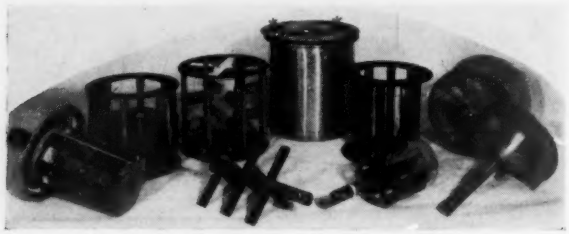

FIG. 3.—Rotors and stators for attrition scrubber.

Certain conclusions which apply to this scrubber may be drawn from these tables, but similar results should be obtained for a larger machine. An experiment conducted with a scrubber, similar to impeller No. 1 but smaller and having different proportions, indicates that capacity is approximately proportional to volume at the same speed of rotation.

TABLE II

EFFECT OF VARIATION OF WORK INPUT*

Sample No.	Work (h.p.-hr./T.)	Sand	Fe_2O_3 (%)
170	30	Jean	0.063
171	15	"	0.070
172	10	"	0.068
173	5	"	0.069
174	2½	"	0.070
6	0	"	0.120
165	30	Baltimore	0.071
164	15	"	0.091
158	10	"	0.080
463	5	"	0.120
166	0	"	0.190
283	100	Silica	0.026
SS1	30	"	0.038
SS2	17	"	0.039
SS3	8	"	0.051
SS4	2½	"	0.048
SS5	0	"	0.073
SS6	40	Berkeley (washed)	0.0171
SS7	20	"	0.0162
SS8	10	"	0.0163
SS9	5	"	0.0164
SS10	2½	"	0.0173
SS11	0	"	0.0181

* On all samples except No. 283, (*a*) peripheral speed is 1750 ft./minute; (*b*) impeller No. 1 used; (*c*) sample weight, 1000 gm.; (*d*) solids, 50%; (*e*) input, 0.15 h.p.
For sample No. 283: (*a*) peripheral speed, 3475 ft./minute; (*b*) impeller No. 2 used; (*c*) sample weight, 1500 gm.; (*d*) solids, 50%; (*e*) input, 0.725 h.p.

(1) Unless the stain is exceptionally tough, 2½ to 10 h.p.-hr. per ton removes almost all of the removable stain (Table II, Fig. 4). Further work results in very little iron removal. The description of the scrubber[3] gives no data on probable power expenditure, and the principal comment from possible users was that it probably would consume a great deal of power. The addition of a dynamometer that measures the actual power consumed in the attrition cell showed that only a moderate, measurable amount of power was needed to bring a definite sand to a definite degree of purity.

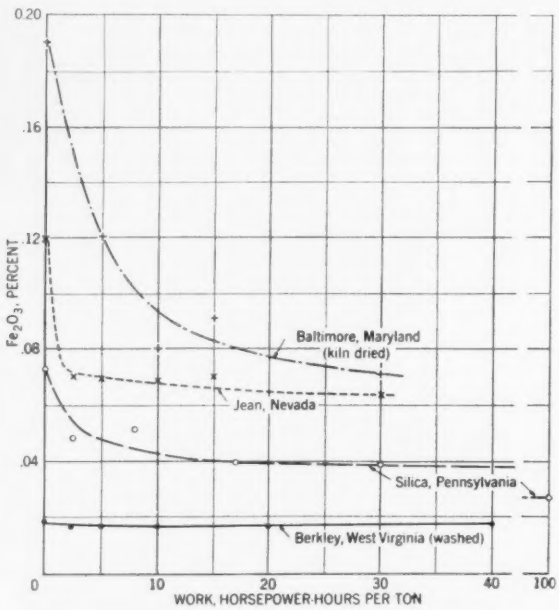

FIG. 4.—Effect of work input on stain removal.

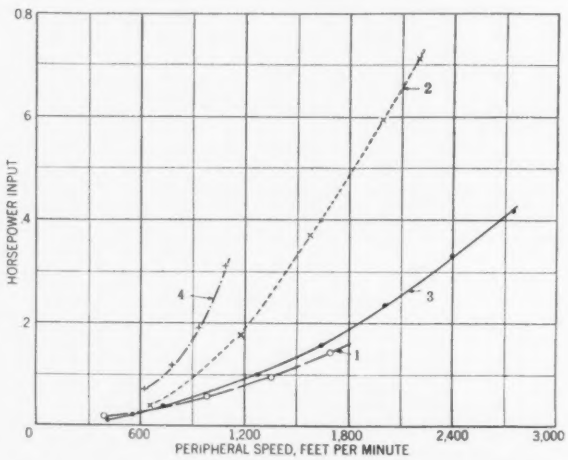

FIG. 5.—Effect of speed on power input for different rotors and stators; sand pulp solids 50%.

Rotor and Stator No.	Blades (type)	Sand charge (gm.)
1	Vertical	1000
2	Horizontal	1500
3	Vertical	1500
4	Horizontal	1500

(2) Greater efficiency is obtained with a relatively larger charge than with a smaller one in a batch machine (Table III). This is due, at least in part, to the constant amount of untreated sand that remains in corners and other dead spaces throughout the test; it may also be due to the fact that the power input is disproportionately higher for the larger charge.

(3) The horizontal-bladed rotors and stators (Tables II and IV) absorb more power for the same peripheral speed (Fig. 5) and much more power for the same speed of rotation than the vertical-bladed impellers, Nos. 1 and 3. Their capacity therefore is much greater and they are also somewhat more efficient (Tables I and V). Because the degree of wear increases with peripheral speed, the horizontal-bladed scrubbers will have less wear per ton of material treated.

(4) Although the relative quantities of sand and water have an important bearing on the efficiency of stain removal, there is no one definite proportion for all conditions. A definite peak of scrubbing efficiency is observed in Table IV for moderate speeds with impeller

TABLE III

EFFECT OF AMOUNT OF CHARGE*

Sample No.	Sample wt. (gm.)	Solids (%)	Input (h.p.)	Sand	Fe_2O_3 (%)
172	1000	50	0.15	Jean	0.063
181	750	"	0.065	"	0.103
158	1000	"	0.15	Baltimore	0.08
159	600	"	0.042	"	0.11
160	800	40	0.13	"	0.12
161	400	"	0.033	"	0.13

* Peripheral speed, 1750 ft./minute; impeller No. 1 used throughout; work per ton, 10 h.p.-hr.

TABLE IV

EFFECT OF DENSITY OF PULP*

Sample No.	Peripheral speed (ft./min.)	Sample wt. (gm.)	Solids (%)	Input (h.p.)	Sand	Fe_2O_3 (%)
			Impeller No. 1			
179	1750	250	20	0.065	Jean	0.094
178	"	429	30	0.077	"	0.097
177	"	667	40	0.093	"	0.067
172	"	1000	50	0.15	"	0.063
175	"	1000	60	0.073	"	0.071
176	"	1000	70	0.045	"	0.074
162	1750	200	20	0.040	Baltimore	0.110
160–61	"	800–400	40	0.067	"	0.125†
158–59	"	1000–600	50	0.077	"	0.095†
156–57	"	1000–600	70	0.026	"	0.120†
			Impeller No. 2			
296	853	1000	30	0.089	Silica	0.053
295	"	"	40	0.057	"	0.061
294	"	"	50	0.048	"	0.065
293	853	1500	40	0.09	"	0.058
291	"	"	60	0.07	"	0.059
285	"	"	71	0.08	"	0.065
292	"	"	75	0.09	"	0.051
309	2250	1000	30	0.55	"	0.058
308	"	"	40	0.44	"	0.055
297	"	"	50	0.405	"	0.053
298	"	"	60	0.24	"	0.048
299	"	"	75	0.102	"	0.045
347	853	500	30	0.042	Brentwood amber	0.12
346	"	700	40	0.042	" "	0.11
343	"	1000	50	0.048	" "	0.11
344	"	1300	60	0.055	" "	0.096
345	"	1650	70	0.065	" "	0.087
352	2250	500	30	0.37	" "	0.125
351	"	700	40	0.35	" "	0.105
348	"	1000	50	0.405	" "	0.083
349	"	1300	60	0.43	" "	0.086
350	"	1650	70	0.39	" "	0.078
			Impeller No. 3			
327	918	800	30	0.056	Silica	0.055
330	"	1500	50	0.061	"	0.046
326	"	2500	70	0.09	"	0.054
329	1860	800	30	0.18	"	0.055
325	"	1500	50	0.28	"	0.054
328	"	2500	70	0.285	"	0.036

* Work = 10 h.p.-hr./T. throughout.
† Average of 2 tests.

TABLE V

EFFECT OF SPEED*

Sample No.	Peripheral speed (ft./min.)	Solids (%)	Input (h.p.)	Fe_2O_3 (%)
		Impeller No. 1		
269	440	50	0.013	0.052
270	900	"	0.039	0.052
271	1800	"	0.13	0.048
		Impeller No. 2		
275	525	50	0.024	0.065
276	900	"	0.125	0.076
280	1880	"	0.27	0.048
297	2250	"	0.405	0.053
281	2820	"	0.60	0.046
282	3475	"	0.725	0.045
		Impeller No. 3		
322	452	50	0.012	0.051
323	918	"	0.061	0.053
324	1377	"	0.175	0.054
273	1744	"	0.20	0.050
325	1835	"	0.28	0.050
286	2980	"	0.34	0.051
		Impeller No. 4		
331	720	47	0.085	0.054
332	900	50	0.175	0.046
334	1170	53	0.355	0.040

* Silica, Pa., sand used throughout; sample weight was 1500 gm. except for samples Nos. 269 to 271, which were 1000 gm. each; 10 h.p.-hr. work per ton used throughout.

No. 1 at 50% of solids. Power input, however, is at a maximum at 50% of solids. The pulp should be thick enough to absorb a maximum of power to avoid wasting energy on the water but not too thick to flow back to the zone of action. For rotors and stators whose zone of action is large, such as Nos. 2 and 3, this is not so important, and pulps up to 70% of solids may be used.

(5) The efficiency increases with power input, and the capacity also increases. For this size of scrubber, however, a power input in excess of 0.5 h.p. results in appreciable comminution. There is, therefore, a limit

TABLE VI

EFFECT OF SCRUBBING MEDIUM*

Sample No.	Medium	Weight (gm.) Sand	Weight (gm.) Medium	Solids (%)	Input (h.p.)	Work (h.p.-hr./T. solids)	Fe_2O_3 (%)
335	Zircon	750	750	50	0.58	5	0.046
336	Garnet	750	750	"	0.675	5	0.046
297	None	1500	0	"	0.405	10	0.047
339	Garnet	1000	500	"	0.69	$6^2/_3$	0.042
336	"	750	750	"	0.675	5	0.046
340	"	500	1000	"	0.69	$3^1/_3$	0.050
337	Zircon	750	750	67	0.37	5	0.042
335	"	750	750	50	0.58	5	0.046
338	"	500	500	33	0.8	5	0.050

* Impeller No. 2; 2100 to 2200 ft./min. peripheral speed; Silica, Pa., sand used; 10 h.p.-hr. work/ton of sand.

TABLE VII

EFFECT OF CHEMICAL TREATMENT*

Sample No.	Chemical	(lb./T.)	Soaking time	Washed out before scrub	Speed (r.p.m.)	Sample wt. (gm.)	Input (h.p.)	Work (h.p.-hr./T.)	Fe_2O_3 (%)
287	NaOH	10	0	No	1880	1500	0.27	10	0.063
288	"	"	0	No	2950	"	0.63	100	0.036
280	O		0		1880	"	0.27	10	0.048
283	O		0		3475	"	0.725	100	0.026
297	O		0		2250	1000	0.405	10	0.053
313	O		16 hr.		"	"	"	"	0.056
314	O		2 wk.		"	"	"	"	0.049
315	NaOH	2	16 hr.	No	"	"	"	"	0.041
316	"	"	" "	Yes	"	"	"	"	0.048
317	NaOH	10	2 wk.	No	"	"	"	"	0.048
318	"	"	" "	Yes	"	"	"	"	0.040
341	Santomerse	1	0	No	"	"	"	"	0.049
342	Lupomin	0.4	0	No	"	"	"	"	0.046

* Impeller No. 2 used; solids, 50%; Silica, Pa., sand.

TABLE VIII

EFFECT OF SCRUBBING ON PARTICLE SIZE*

		Power input (h.p.-hr./T.)					
	0 (Feed)	$2^1/_2$	5	10	20	40	
		Change from feed analysis (%)					
Size	Cum. (%)						Cum. (%)
+ 20	2.30	−0.40	−0.55	−0.15	−0.65	−0.65	1.65
+ 30	6.70	−0.60	−0.80	+0.20	−1.25	−0.75	5.95
+ 40	26.20	−1.70	−1.8	−0.35	−3.05	−2.10	24.10
+ 50	70.50	−0.85	−1.65	+0.65	−0.60	−0.70	69.80
+ 70	93.60	−0.60	−0.75	+0.45	−0.85	−1.00	92.60
+100	99.00	−0.20	−0.40	−0.10	−0.40	−0.55	98.45
+140	99.80	−0.05	−0.15	0.00	−0.15	−0.20	99.60
Fe_2O_3 (%)	0.0181	0.0173	0.0164	0.0163	0.0162	0.0171	

* Impeller No. 1 used; solids, 50%; speed, 1800 r.p.m.; sample weight, 1000 gm.; input, 15 h.p.

to the power input and capacity, which is just short of the intensity of action needed to break the grains.

(6) The scrubber is a small, compact machine; the laboratory machine, which is $6^3/_4$ in. in diameter by $7^1/_2$ in. with an input of 0.5 h.p., will treat 1.2 tons per day with 10 h.p.-hr. per ton or 4.8 tons per day with $2^1/_2$ h.p.-hr. per ton. The scrubber is smaller than the motor that drives it.

(7) The horizontal-bladed rotors (Nos. 2 and 4) are most efficient at high speed, perhaps because the power input increases disproportionately with increase in speed. The vertical-bladed rotors (Nos. 1 and 3), whose power input is approximately proportional to speed, are as efficient at slow speeds as at high speeds (Table V).

(8) The addition of such scrubbing mediums as garnet and zircon grains effects only a slight increase in efficiency (Table VI). The small saving of power is probably insufficient to pay for the removal of the mediums later by tabling or magnetic separation.

(9) The use of moderate amounts of alkali or surface-active agents resulted in little, if any, benefit for the one sand that was tested for this effect (Table VII).

(10) No appreciable comminution occurs at moderate power input (Table VIII). Even when 40 h.p.-hr. per ton are used, only a slight rounding of the grains may be observed.

The attrition scrubber, therefore, is a compact machine that provides a severe agitation adequate for the removal of tough stains of ferruginous clay or iron oxides from the surface of sand grains without breaking the grains.

III. Examples of Treatment and Results

Many samples have been submitted to the Eastern Experiment Station for testing since the report by Norman and Ralston was published.[3] Some of the results of these tests are shown in Table X. A few of the samples were submitted at the request of the authors to acquire a wide variety of samples of sands now being produced.

TABLE IX
EFFECT OF SCRUBBING ON FLOTATION FEED

Reagents (lb./T.)	Scrubbed			Not scrubbed		
R_1 oleic acid	1.3			0.7		
R_2 Na_2CO_3	2.0			0.5		
	Wt. (%)	Fe_2O_3 (%)	CaO (%)	Wt. (%)	Fe_2O_3 (%)	CaO (%)
R_1	0.5	0.68	High	4.0	0.18	High
R_2	0.3			37.0	0.016	0.22
Float underflow	99.2	0.010	0.09	59.0	0.011	0.20
	100.0	0.015	0.25	100.0	0.020	0.40

The test procedure is usually as follows:

(1) Determine by inspection or by microscopic examination (*a*) whether iron compounds are present as stain or discrete grains or both and (*b*) the other principal impurities.

(2) Determine the amount of +20-mesh grains or aggregates that are difficult to break; examine the finest fraction and the coarsest fraction for segregation of impurities.

(3) If iron is mainly stain, use attrition scrubber.

(4) If scrubber is insufficient or ineffective, try acid leaching with 1 to 1 HCl.

(5) If iron occurs mainly in discrete grains, table or make flotation test or both; if grains are coarse, make agglomerate tabling test; also make magnetic separation tests.

(6) If both specks and stains are present, try flotation with and without scrubbing.

(7) Examine the results, select the best methods, and continue the test to determine the amount of power required for scrubbing or the amount of reagents required for flotation.

Because sands are the most unaltered end product of weathering, the impurities, if not resistant to weathering, are in greatly altered condition; even the surfaces of apparently clean quartz grains are covered with impurities other than iron compounds.

As flotation is a surface phenomenon, the minerals present in sands usually do not behave naturally unless they are cleaned. Scrubbing produces clean surfaces so that minerals behave naturally. Table IX shows the improvement on flotation feed made by scrubbing. The sand, from Rockwood, Mich., is cemented with iron-containing dolomite.

The reagents shown are those used, not those required. An excess of reagent is used on clean-surfaced minerals as a time-saving convenience in testing. An insensitive, selective separation is desirable in flotation. Clean quartz will not float even with an excess of oleic acid at any pH. Quartz floats in neutral circuit only when it is badly activated, but slightly dirty quartz will float in an alkaline circuit. Thus about 40% of the quartz will float without scrubbing; but, with scrubbing, twice as much of the collector and four times as much alkali is not sufficient to float more than a few grains of quartz.

Dirty quartz may be depressed in slightly acid circuits so that it will not float with oleic acid, but the floatability of iron-containing minerals may also be decreased. Flotation, therefore, of iron-bearing impurities from sand, even with no visible iron stain, is improved by scrubbing the flotation feed.

Tabling or classification and tabling are unaffected by surface coating, and heavy iron minerals may usually be rejected in this way.

If the iron-bearing grains, such as mica and feldspar, are not heavy or very magnetic, the gravity and magnetic processes are ineffective, but flotation will remove these impurities efficiently.

IV. Summary

Iron, the most prevalent and deleterious impurity in glass sands, occurs in many forms that may be divided into two classes, namely, stains and discrete grains of iron-bearing minerals.

Some stains are easily washed off or rubbed off during grinding; others are more difficult to remove, but the acid-leaching or attrition-scrubbing processes are successful.

TABLE

EXAMPLES OF

Source of sand	Description: Fe_2O_3 (%)	Description: Principal impurities	Description: Consolidation	Description: Character of coarse sand	Scrubbing tests: Pretreatment	Scrubbing tests: H.p.-hr./T.	Scrubbing tests: Fe_2O_3 (%)	Scrubbing tests: Rotor	Flotation and agglomera- tion: Pretreatment	Flotation and agglomera- tion: Type*
Millville, N. J.	0.11	Ilmenite, zircon, etc.	None	None	None	10	0.11	1	None	Anionic
										Anionic and agglom.
Berkeley, W. Va.	0.024	Soft stain	Soft quartzite	Aggregates	Ground in chaser mill	2.5	0.015	"		
Mapleton, Pa. (II)	0.042	" "	" "	"	" " "	2.5	0.031	"		
Zanesville, Ohio	0.027	Clay stain	Slight	2% + 20-mesh Fe_2O_3 0.107%	None	10	0.023	2		
					"	20	0.020	"		
					Mag. sep.	5	0.019	"		
Rockwood, Mich.	0.035	Iron in dolomite cement	Hard to soft	+20-mesh Fe_2O_3 0.17%	−20	10	0.0094	"	None	Anionic
	(−20)				−20	20	0.011	"	Scrub	"
	(0.020)				Mag. sep.	5	0.010	"		
Wedron, Ill.	0.030	Clay stain, high-iron balls	Slight	Hard, high-iron balls can be scalped out	None	10	0.013	"		
	(−20)				"	20	0.011	"		
					Mag. sep.	5	0.0115	"		
Crosley, Fla.	0.028	Clay and mica	None	3% + 20-mesh	None	10	0.0135	"	None	Cationic
					"	20	0.016	"		
					Mag. sep.	5	0.0063	"		
Ada, Okla.	0.074	High-iron balls and clay	Slight	+ 35-mesh, mostly iron balls	Scalp	10	0.018	1	Scalp	Anionic
					Floated	10	0.012	"	Scrub	"
					Mag. sep.	10	0.012	"		
Mt. Diablo, Calif.	0.074	Feldspar, specks, carbonaceous chert	"	None					None	"
									"	Anionic and cationic
Brentwood, Calif.	0.12	" "	"	"	None	10	0.078	2	Scrub	Cationic
									"	Cationic float and cationic agglomerate
Cape Cod, Mass.	0.29	Feldspar, specks, stain	None	"	Mag. sep.	10	0.22	1	Mag., scrub	Cationic float
Stonington, Conn.	0.10	Mica	Soft silica rock	Lower in Fe_2O_3	Ground −20-mesh	10	0.029	"	−20-mesh	Anionic
					Ground and tabled	10	0.020	"	" "	Anionic and cationic
Silica, Pa.	0.073	Stain, specks	Soft quartzite	Aggregates	Ground −20-mesh	100	0.026	2		
Pa. sands (misc.) B	0.20	Stain, specks	(?)		None	8	0.136	1		
						17	0.133			
Pa. sands (misc.) D	0.097	" "	(?)		"	8	0.073	"		
						17	0.059	"		
Rochester, N. Y.	0.48	Stain	(?)		"	20	0.32	1		
Baltimore, Md.	0.19	Kyanite, stain	None	From gravel bank	Table	10	0.080	"		Anionic
Howard, Ga.	0.12	Stain, specks, mica	(?)	None	None	8	0.073	"	Scrub	Anionic and cationic
Brentwood, Calif.	0.20	Feldspar	Slight	"	"	10	0.078	2	"	Float and agglomer- ate
Overton, Nev.	0.057	Stain, specks	(?)	"	"	10	0.045	"	None Scrub	Anionic "

* Flotation, unless noted.
† 1-1 HCl, hot, unless noted.

Discrete grains may be removed by gravity-separation methods if they are heavy; by magnetic separation if they are high in iron; or by froth flotation, regardless of their properties.

For sands that have both discrete grains and stain impurities, acid leaching removes the stain and some of the specks; flotation removes the specks and some of the stain.

The attrition scrubber is a small, compact agitator that, with moderate power consumption, will produce the severity of action that will rub together grains of the pulp to remove their stained and dirty surfaces.

Flotation may be used to remove iron-bearing grains even if they are not heavy or magnetic enough to be removed by other methods. Scrubbing before flotation improves flotation results by cleaning the surfaces.

The attrition scrubber is available to all interested users without license or other fees. It is hoped that it will be useful and will lead to an improvement in glass sands and that it may result as near as possible to the use of sands to the point of consumption.

Acknowledgments

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X

TREATMENT AND RESULTS

tion tests	Acid leaching		Magnetic separation					
Fe_2O_3 (%)	Acid†	Fe_2O_3 (%)	Prod.	Fe_2O_3 (%) Before	After	Other treatment	Present industrial treatment	Recommended treatment	Remarks
0.025 0.025							Tabling to 0.025% Fe_2O_3 product	Same or flotation	Ilmenite and zircon may be recovered and sold
		0.011					Grind and wash to 0.015% Fe_2O_3 product	Same	Oriskany sand
							Grind and wash to 0.031%	"	Off-grade Oriskany sand
	H_2SO_4	0.019 0.018	Feed	0.027	0.021		Leaching with hot H_2SO_4	Scrub if Fe_2O_3 0.020% is salable	
0.011 0.010			"	0.020	0.018	Diff. grind and scalp; −20-mesh 0.020%	Unknown	Diff. grind; scalp on 20-mesh	Hard rock is high in lime and iron
			"	0.030	0.030	Scalp	Washed to 0.011	Wash	St. Peter sandstone
0.007			"	0.028	0.016	Scalp and grind	Clay washed out; sand by-product	Float before drying; deslime	Clay washery tailing
0.017 0.012		0.028	Scrub	0.018	0.012	Scalp	Formerly scalp 16-mesh; wash to Fe_2O_3 0.030%	After test, scalp at 30-mesh; wash to 0.020%	Scalping reduces iron to 0.064%
0.061 0.055		0.038	Feed	0.074	0.042	Table and sink-and-float 0.054 and 0.050%	Flotation of specks with xanthate	Flotation with oleic acid	Flotation tailing; deposit has Fe_2O_3 0.11%
{ 0.059 { Al_2O_3 0.5% 0.035 Al_2O_3 0.13%							Wash and acid leach to 0.045% Fe_2O_3, 3.5% Al_2O_3 product	Same or blend with amber; scrub and leach	Flint sand; cannot be sold at same price without Al_2O_3
(?)			"	0.29	0.26		None	None	Treatment cost excessive; sample contains 27% of feldspar
0.025 0.013			"	0.10	0.035		(?)	Flotation or tabling and scrub	Silex mine
	Adams	0.016					Grind; wash for 0.06% Fe_2O_3 product	Same; too close to good deposits	Control sand (see Tables II–VIII)
		0.052	Scrub (17)	0.133	0.166		None	None	Stain dried before treatment
		0.033	"	0.059	0.038		"	Too close to good deposits	" " "
	HCl-HF	0.16 0.088	"				"	None	Colored glass; only possible use
Kyanite removed						Table to remove kyanite	Sold for blue glass	Table to remove kyanite	Kyanite caused stones in glass
0.017							None	Scrub to 0.06% Fe_2O_3 product	Possible development for new southern glass plant
0.018 Al_2O_3 0.12%		0.107					Not mined	Scrub and leach to 0.047% Fe_2O_3 product	Amber sand; see flint sand above
0.038 0.036			Feed	0.057	0.043		(?)	Float	Very fine-grained sand

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SYMBOLISM IN CHINESE PORCELAIN DECORATION*

By Chao Ming Chen

Abstract

The sources of symbolism in Chinese porcelain decoration are summarized as those of (1) legend, (2) religion, (3) history and philosophy, and (4) Chinese customs. Brief stories concerning these symbolic decorations are told, and the accompanying photographs illustrate the designs which are described.

I. Introduction

The civilization of China is more than five thousand years old, and its culture has developed from time to time during that period. Any topic, therefore, relating to a special field requires a long time to describe, and the present subject is one of the most important topics on Chinese culture.

The Chinese who make pottery and porcelain ware with a special symbolism have fundamentally a double purpose; first, the ware must bear such outstanding characteristics as excellent workmanship, graceful forms, fine materials, and schemes of coloration that will preserve its existence for an indefinite period, and second, it must serve as an object that will give great pleasure to those who own it, particularly the pleasure in seeing the symbolism arrayed on a particular piece. The Chinese people, strictly speaking, are a conservative race, and the decorations on Chinese porcelains are a lesson which serves as a motto to a family or to a person who will talk about them and display them.

II. Sources of Symbolism

The sources of symbolism are many and complicated, but they may be roughly summarized into four headings, namely, those derived from (1) legendary origin, (2) religious sources, (3) historical and philosophical sources, and (4) Chinese customs.

(1) Legendary Origin

(*A*) *Pa-Kua, Eight Trigrams:* The most important illustration of this kind is the symbol Pa-Kua, Eight Trigrams, originated by the legendary Emperor Fu Hsi (3333 B.C.). Chinese history states that when Emperor Fu Hsi ascended his throne a mystic diagram was revealed to him on the back of a dragon-horse, half dragon and half horse, which rose from the Yellow River. Figure 1 shows these symbols. It is a picture of an imperial bronze glaze porcelain plate of the Ch'ien Lung period (1736–1795), molded into the form of a fruit plate with foliated rim, key fret design, and eight symbols of auspicious clouds around the mouth. The Pa-Kua design was originated from ancient hieroglyphics as follows: (*a*) the three unbroken lines, ☰, called by the Chinese "Ch'ien," mean "heaven" or "father"; (*b*) the three broken lines, ☷, called "Kun," "earth" or "mother"; (*c*) two broken lines with one unbroken line, ☳, called "Chen," "eldest son"; (*d*) two unbroken lines with one broken line, ☴, called "Sun," "eldest daughter"; (*e*) one unbroken line between two broken lines, ☵, called "Keng," "second son"; (*f*) one broken line between two unbroken lines, ☲, called "Li," "second daughter"; (*g*) one unbroken line with two broken lines, ☶, called "Ken," "youngest son"; and (*h*) one broken line with two unbroken lines, ☱, is "Tui," "youngest daughter."

The symbol Pa-Kua, Eight Trigrams, has been used for more than five thousand years in China, and it is seen in nearly every Chinese home in various forms of decorations or even on doorframes. Many modern thinkers believe that the symbol Pa-Kua is really the symbol of Noah in the Old Testament, who with his wife, three sons, and three daughters, was saved after the Flood. According to the Babylonian story of the Flood on Akkadian cunieform tablets in the British Museum, which were first deciphered in 1872, it is part of an epic in twelve parts, each connected with a sign of the Zodiac. The Flood story is the eleventh part and is connected with Aquarius, the waterbearer.

Fig. 1.—Imperial bronze glaze porcelain plate of Ch'ien Lung period (1736–1795); $2^{5}/_{8}$ by $14^{1}/_{4}$ in.

* Presented at the Forty-Third Annual Meeting, The American Ceramic Society, Baltimore, Md., April 3, 1941 (Art Division). Received April 3, 1941.

The date of these tablets is at least 3000 B.C. It probably passed through a long period of oral repetition before it reached the Hebrews, who changed many of the incidents to make it illustrate spiritual truth.

In the center of this plate is the symbol of Yin and Yang, which symbolizes the duality of nature. Yin, the female, and Yang, the male, are bisected by a wavy line. The doctrine of Yin and Yang was fully described in the Book of Changes, which was edited by Confucius. The ancient philosophers believed that the universe was created by an element which could not be definitely named, so the name was used in Chinese with two characters "Tai Chi." The explanation of "Tai Chi" was that before Heaven and Earth were created all of the matter was mixed into only one body, thus, the expression "Tai Chi"; "Tai Chi," however, consists of two elements which the Chinese call Yin and Yang. Now from Yin and Yang Heaven and Earth were created. This was followed by the creation of the four elements, namely, metal, wood, water, and fire, as well as the sun, moon, and stars. After this had been accomplished, the Pa-Kua was created.

(*B*) *The Dragon:* The Chinese believed in an animal called the "dragon," which appeared in remote times and is recorded in the second sentence of the Book of Changes that was edited by Confucius (522–479 B.C.). The dragon is depicted by the Chinese with "long-bearded, scowling head, two straight horns, a scaly serpentine body with four feet protected by claws, a line of bristling dorsal spines, and flames proceeding from its hips and shoulders." The dragon was designated in ancient times as a most powerful creature that could render the storm and bring thunder and rain, but there was no specification of the claws on its four feet. This distinction was not established until the 6th century by the famous master of dragon painting, Chang Séng-Yu. Since then, the significance of the claw has been distinguished by five claws for the Emperor; four claws for the Prince, nobles, and high ranking officials; and three for lower ranking officials. When you see a decoration of nine dragons on porcelains or embroideries, it means they were made for the enjoyment of the reigning monarch; there must be one with a full face among the nine because he represents the Emperor. The Chinese belief in the dragon began in a very primitive period.

Figure 2 shows one of a pair of unusual imperial porcelain seals coated with a fine, even jet black glaze on the top and four narrow sides. A vigorous five-claw running imperial dragon, surrounded by flames and pursuing the pearl, amid auspicious clouds, appears on each of the narrow sides. The horns of two imperial dragons joined together form the handle. Between the heads, modeled on the top of the seal, is a green dragon brought out in relief, with a front view which symbolizes the sovereign himself as the ruler of the world. The other dragons are decorated with fine enamel colors, the result of the high development of porcelain under the Emperor K'ang Hsi (1662–1723) when this seal was made. The face is carved in seal style, with eight Chinese characters, meaning the imperial seal certifying the objects that were examined by the Emperor K'ang Hsi. The other seal of the pair is in the same design, of the same size, but with different wording, "Imperial seal certifying the objects admired by the Empress Hsiao I." This pair of imperial seals is thought to be the only ones of their kind in existence; they have been fully described by the famous connoisseur of Chinese art, the late Berthold Laufer (curator at the Field Museum of Natural History, Chicago, September 25, 1933).

Figure 3 shows a carved imperial porcelain scepter which was made during the Ch'ien Lung period (1736–1795). It is of a varied green porcelain to resemble jade, elaborately carved. A dragon with an upright head is coiled on the head of the scepter, the position on everything used by the Emperor. On the forehead of the dragon is a Chinese character "Wang," meaning "king." The body is carved with two imperial dragons looking toward a symbol of three characters "Shou," meaning "longevity." The end of the scepter is carved with the Chinese characters, "Shuang Hsi," meaning "double prosperity." These two words are used only in wedding decorations. This scepter was made for the Emperor's wedding day.

FIG. 2.—Emperor's seal, K'ang Hsi period (1662–1723); $7\frac{1}{2}$ in. square, almost 6 in. high.

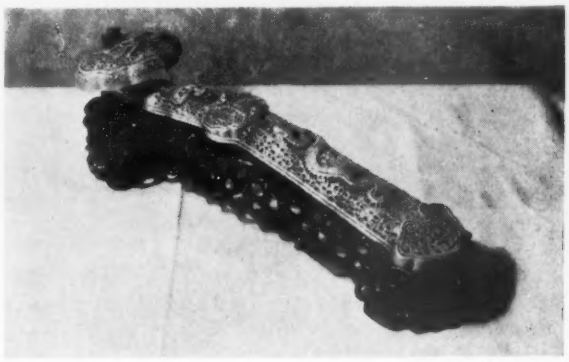


FIG. 3.—Imperial scepter (Ju-I), Ch'ien Lung period; $18\frac{3}{4}$ in. long.

(*C*) *Unicorn:* Ch'i Lin (unicorn), commonly called Kylin, consists of Ch'i (male) and Lin (female). It has "the body of a deer with slender legs and divided hoofs, a head resembling that of a dragon, tail curled and bushy like that of a conventional lion, and shoulders adorned with flamelike attributes of its divine nature. It is said to attain the age of one thousand years. The unicorn represents the noblest form of animal creation. It is the emblem of perfect good; it treads so lightly that it leaves no footprints and so carefully that it crushes no living creature." Its appearance signifies the coming of a virtuous ruler. The Chinese belief in the unicorn also started in the primitive period and has been mentioned in the Chinese classics by Confucius. When a virtuous ruler comes, the Ch'i Lin appears. The Chinese believed Confucius was a representation of Ch'i Lin, because a unicorn appeared when he was born.

FIG. 4.—Carved ivory seal attributed to Sung period (959–1278); $3^{3}/_{4}$ by $2^{3}/_{8}$ in.

When Confucius heard that a Ch'i Lin was killed in a field outside his city, he threw his brush away and predicted that he would die very soon. His prediction came true. The Chinese also believe that Ch'i Lin carries one hundred different kinds of treasures, and this symbolism is employed in different materials of art objects. The writer, unfortunately, has no photograph of a porcelain figure of Ch'i Lin, but he possesses a carved ivory seal with a full figure of a unicorn for a handle. This seal is attributed to the Sung period (959–1278) and has a circular bottom where Chinese characters, in seal style, are carved. The handle is carved in the design of a unicorn (emblem of perfect good) sitting on its haunches and supporting itself by its front legs. Its open mouth displays its teeth and there is one horn on the back of its head. Flames are spreading on the sides. Figure 4 gives an excellent idea of a unicorn.

(*D*) *Horse:* The horse is also a popular design for decorating Chinese porcelains. Usually eight horses of different postures are used to symbolize the story of the expedition of King Mu of the Chou dynasty (1001–951 B.C.) to the far west. He had celebrated chariot horses which were managed by the famous rider, Tso Fu, who helped King Mu drive in different directions for the enjoyment of his trip.

(*E*) *Birds:* According to the Book of Rites, there are three hundred and sixty different kinds of birds. The Fêng-Huang, or phoenix, is the leader and is a special emblem for the Empress. It is one of the most significant decorations on Chinese porcelains. According to Chinese history, Fêng-Huang is a divine bird (Fêng meaning male, Huang, female). It is always more than six feet high and is usually portrayed with

FIG. 5.—Blue porcelain vase decorated with white slip, Ch'ien Lung period.

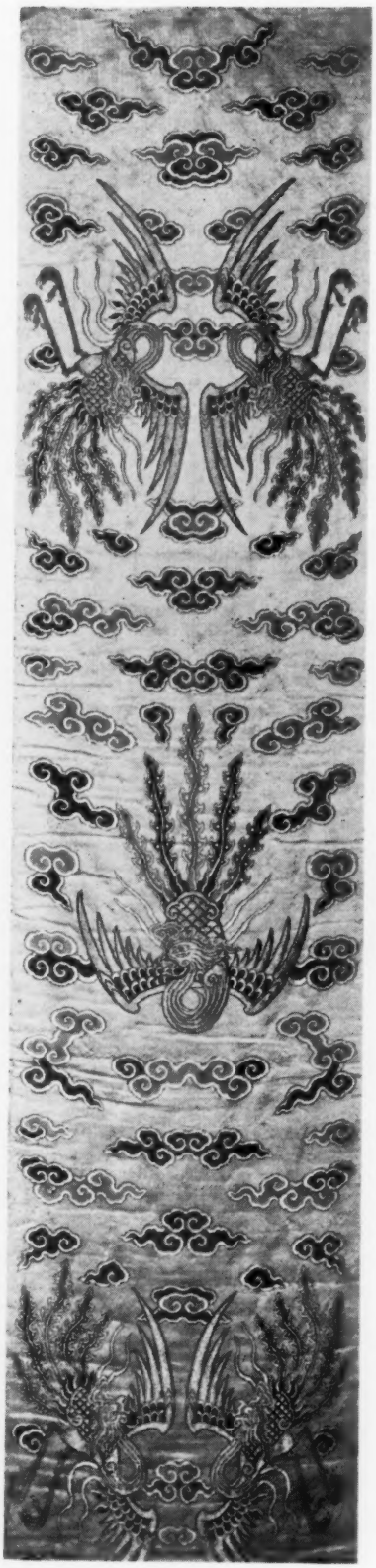


FIG. 6.—Imperial tapestry of phoenix, K'ang Hsi period; $76^1/_2$ by $13^3/_8$ in.

FIG. 7.—Blanc de chine Kuan-Yin figure, Ming dynasty (1368–1643); $17^1/_2$ in. high.

"the head of a chicken, the brow of a swallow, a snakelike neck, the body of a bird, and a flowing fish tail that curls and separates into five parts at the end with plumage of many gorgeous colors. It has long claws pointed backward as it flies." The Chinese believe Fêng-Huang was before the time of Confucius, who claimed that when the Fêng-Huang arrived peace would reign throughout the world.

Figure 5 shows a white slip porcelain vase with a blue background, decorated in the design of peony flowers (riches) and phoenix. This vase was made during the reigning years of the Emperor Ch'ien Lung (1736–1795) and has a graceful form with exquisite workmanship in decoration. The phoenix, however, is not in full detail. A palace hanging of imperial yellow silk, Fig. 6, was made during the K'ang Hsi period (1662–1723). It is executed with gold thread and colored silks; in the center, an imperial phoenix is flying down from auspicious clouds with curled neck and head in an upright position which corresponds to the full-face imperial dragon. There are two imperial phoenixes above and below it, the upper with spreading wings as if flying, necks curled downward, and heads resting against their bodies; those below are in the opposite pose so that they face each other. The bottom shows the "Rock of Ten Thousands of Years" emerging from the waves, which is usually seen with the imperial dragon. This piece was made for the wedding of the Emperor; the phoenix represents the Empress and the dragon, the Emperor.

In addition to the phoenix, there are quite a few birds which are popularly used in decorations. The peacock represents glory; the magpie, depicted with the prunus or plum flower, is representative of a distinguished and prominent person; the thrush, with the bamboo, means humble and fine in character; the stork and crane represent longevity; the Mandarin ducks, conjugal affection; and the cock is the bird of fame. Some birds are associated with special trees and flowers; for example, swallows with the willow, partridge and quails with millet, and pheasants with peonies and magnolias. Sometimes the phoenix is surrounded by one hundred different kinds of birds, which means that she is the leader. The crow is considered unlucky. Many Chinese believe that when the crow caws outside, it indicates death or tragedy within.

(2) Religious Sources

(*A*) *Gods and Goddesses:* Based on the belief of Buddhism, which has a great variety of gods and goddesses, the most interesting and popular is the image of Kuan-Yin, Goddess of Mercy. This goddess has been depicted in many poses, for example, with many hands, as a Madonna with child, or with a holy boy on one side and a holy girl on the other.

This blanc de chine Kuan-Yin figure, made during the early part of the Ming (1368–1643) period (Fig. 7), has an ivory-white glaze tinged with rose, a superb facial expression, and possesses eyes that seem to follow you in every direction. It is easy to determine the age of this kind of porcelain because of its translucent body with cream or ivory-white glaze which the later productions of this ware lack.

Next in popularity is the jolly monk (Fig. 8). He is Pu-tai Ho-shang, a seminude, corpulent person with a smiling face and a loose robe covering part of his body; he is standing on a circular cushion made of braided palm leaves. In his right hand, he holds a hempen bag containing a child and in his left hand, a pearl. This indicates that he considered a child as precious as a pearl. The body is decorated with three enamel colors, yellow, bluish green, and aubergine; it is carved on biscuit and crackled.

Figure 9 shows a San ts'ai pottery figure of Buddha Sakyamuni seated on a throne. It is dated at the first day of the fifth month of the twelve years of the Emperor Wan Li (1585), of the Ming dynasty. It is decorated with three enamel colors, green, yellow, and blue. The body of the Buddha is yellow, his head is green, the throne is blue and yellow, and the screen is in green and yellow. The date is inscribed in the center

FIG. 8.—Decorated pottery figure of Pu-tai Ho-shang, the jolly monk, Ming dynasty; 19 in. high.

FIG. 9.—San ts'ai pottery figure of Buddha Sakyamuni on throne, Ming dynasty; $17^1/_2$ in. high.

of the screen. The Buddhists worshipped Sakyamuni as the Christians worship Christ.

Figure 10 is K'uei Hsing, God of Learning, who was dismissed by the Emperor, after winning three scholarships, because of his extreme ugliness; he is here represented on a celadon screen. It is a priceless object and was formerly owned by one of the sons of the Emperor Ch'ien Lung. The porcellanous body is molded into the form of an ancestral tablet or screen with a flaring and benchlike stand supported by two feet with a curved hollow space between them. The main feature depicts the belief that the Chinese scholars devotedly worship the image of K'uei Hsing (Ursa Major), the God of the First Seven Stars, who is called the God of Learning and from whom the Chinese scholars desire to obtain intelligible power. The artist depicts the image of K'uei Hsing on both sides of the screen in two forms. One is spiritual, the other physical. It is skillfully carved on biscuit, and the entire tablet is covered with an exquisite pea-green celadon glaze, leaving the soles of the feet (of the stand) uncovered. K'uei Hsing holds a Chinese brush in one hand and a square ink box in the other. Legend tells us that because of his disappointment in being dismissed from court, he decided to commit suicide in the river, but was rescued by the Ao fish, which emerged from the water and carried him to Heaven. Above his head is the design of clouds and seven stars. The Chinese believe he was reincarnated by one of the stars. There are many other gods depicted in porcelains and other materials; among these are the God of Wealth, God of the Mountain, God of the Monkeys, God of Water, and God of the Kitchen.

FIG. 10.—Celadon tablet, Sung dynasty; $7^1/_4$ by $5^3/_4$ in.

(*B*) *Based on Belief of Taoism:* Taoism was established by the famous philosopher, Laotze, a contemporary of Confucius, who learned some special philosophy from him. Many symbols were derived from Taoism which developed from time to time into a large field of superstition credited to the doctrine of Laotze. The Confucianists do not believe entirely in Laotze but have adopted some of his theories. The most famous symbol of Taoism is the Eight Immortals, established during the Yuan period (1278–1368).

FIG. 11.—Porcelain jar of peacock blue with Eight Immortals design, Ch'ien Lung period; $9^3/_4$ in. high.

Figure 11 gives a good idea of the Eight Immortals. This porcelain jar is peacock blue with the Eight Immortals design, which was made during the Ch'ien Lung period (1736–1795). It is molded of buff porcelain into a jar with eight sections depicting in each (carved in high relief) a figure of one of the Eight Immortals with his respective attribute, all crossing the sea. From right to left is (1) Lu Tung-pin with his attribute, the sword; (2) Ts'ao Kuo-chiu and his attribute, castenets; (3) Han Chung-li and his attribute, feathered fan; (4) Chang Kuo and his attribute, bamboo tubes; (5) Li T'ieh-Kuai and his attribute, pilgrim's gourd; (6) Lan Ts'ai-ho and his attribute, basket of flowers; (7) Ho Hsien Ku, the only lady in the group, and her attribute, the lotus blossom, and (8) Han Hsiang-tzŭ and his attribute, musical instrument. The shoulder of this jar is decorated with eight Ju-I (as you wish) designs and eight Buddhist symbols and is covered with a brilliant peacock blue glaze and crackled. It is a unique specimen.

(3) Historical and Philosophical Sources

The symbols of this kind of porcelain are so many that it is difficult to describe in detail. A few which are considered most popular and most frequently used as decorations in Chinese porcelains are described here.

FIG. 12.—Imperial quadrangular vase of three-colored enamel on biscuit; apocryphal mark of Ch'eng Hua (1465–1487), Ming, early K'ang Hsi (1662–1723); 32¾ in. high.

The Seven Sages of Bamboo Forest of the Tsin dynasty (246–420) is one of the most popular. Figure 12 shows a quadrangular porcelain vase, with an imperial

FIG. 13.—Imperial K'ossu painting ordered by Emperor Ch'ien Lung in 1782, showing Gods of Happiness, Longevity, and Rank.

yellow background decorated with colored enamels on biscuit and with the apocryphal mark of Ch'eng Hua (1465–1487), Ming dynasty. It is understood, however, to have been made during the early K'ang Hsi period (1662–1723). It is believed to be one of the tallest imperial yellow vases in existence. The body is decorated with scenery of the Seven Sages of Bamboo Forest. The conventional designs of the God of Happiness, God of Rank, God of Longevity, and God of Prosperity are exquisitely depicted around the neck of this vase.

The decoration on the neck of the vase of Fig. 12 does not show in detail, but Fig. 13 shows an imperial K'ossu painting which was ordered to be made by the Emperor Ch'ien Lung in 1782, with his calligraphy and seals. It pictures the Gods of Happiness, Longevity, and Rank, and through this combination prosperity must result; there are two children to signify prosperity. One offers the God of Longevity a peach, a symbol of long life. A pine tree, peaches, storks, all symbolic of longevity, are also portrayed.

FIG. 15.—Rare porcelain vase of blue and white pilgrim and bottle-shaped, late Ming period; 23¾ in. high, 14 in. in diameter at largest part.

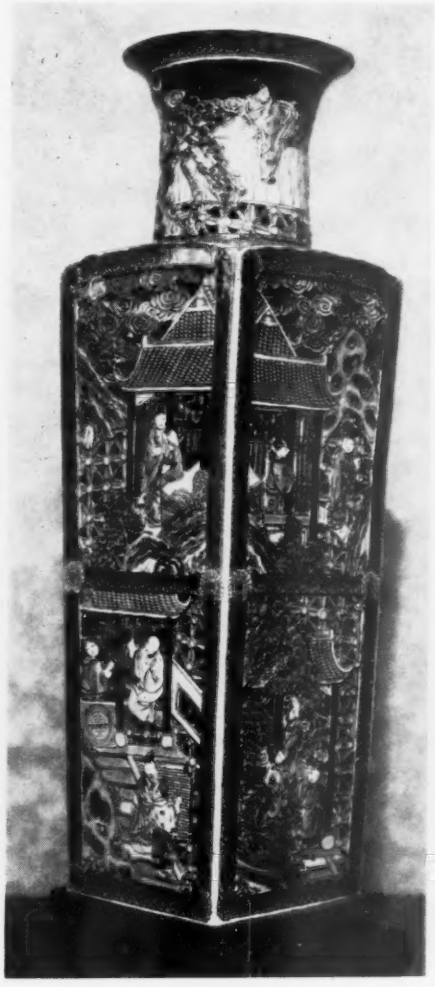


FIG. 14.—Square vase of famille verte, K'ang Hsi period; 20 in. high.

FIG. 16.—Chün Yao tripod, Sung dynasty; 4¾ in. high.

The story of the Twenty-Four Paragons of Filial Piety is next in popularity. China has been established on the foundation of two principles, namely, "Chung," meaning faithful to the country, and "Hsiao," obedience to parents. The stories of Twenty-Four Paragons, therefore, relate to each person how to fulfill his duty to his parents.

Many flowers are listed as attributes to famous scholars and statesmen of ancient times because of their fondness for a particular flower. A particular flower, seen in a design, therefore, represents that scholar or statesman who had a fondness for it. The great poet, Li Po (701–762) of the T'ang dynasty, for example, loved the lotus blossom, and the lotus is representative of him as well as of the scholar, Chou Tun-Hsi, considered to be the leading philosopher of the 11th century (Sung dynasty), who loved it, too. Because the scholar, Tao Yuan-ming (372–427), loved the chrysanthemum and Meng Hao-Jan loved the prunus (plum) flower, these flowers are representative of them. Meng Hao-Jan lived in parts of the 7th and 8th centuries (T'ang dynasty). The Buddhists also designated a kind of lotus flower, which they called the sacred lotus flower, and it is frequently seen in decoration. The orchid bears the meaning of high virtue which was founded by the ruler.

Each month is designated by a special flower, as well as the seasons. The peony (riches) represents spring; the lotus (purity), summer; the chrysanthemum (high virtue), autumn; and the prunus (prominence), winter. Among the trees, the cassia suggests literary honors, as the examination for second and third degrees takes place in the eighth month when the cassia is in full bloom. The willow tree means devotion; the pine and cypress mean longevity; the bamboo, humbleness; the plum, prominence; and the pomegranate, many children. The finger citron means blessed by the Buddha. Sometimes these symbols are shown together, such as the prunus, bamboo, and pine, signifying three good friend-

FIG. 17.—Chien Yao bowl (temmoku), Sung dynasty; $2^{3}/_{8}$ in. high, diameter $4^{1}/_{4}$ in.

FIG. 18.—Five-colored porcelain enamel decorated vase, Wan Li period (1573–1619), Ming dynasty; $24^{1}/_{4}$ in. high.

FIG. 19.—Iron-dust porcelain bowl, Ming period; $4^3/_8$ in. high, diameter, $10^1/_2$ in.

ships, and Confucius, Buddha, and Laotze are also portrayed together as three good friends.

Stories from Chinese novels are also depicted, such as the Dream of the Red Chamber, which has been translated into English. A famille verte square reticulous vase (Fig. 14) of the K'ang Hsi period is made of porcelain with a high neck and an expanded mouth. Each of the four sides is divided into four panels, and each panel depicts part of the ancient Chinese novel, the Dream of the Red Chamber. This vase, without dispute, is a typical K'ang Hsi five-colored enameled decorative motif. No later reproductions of K'ang Hsi porcelains can reproduce such brilliant colors and texture.

There are also symbols of historical sources, based on the bravery and loyalty of the military. Figure 15 shows a blue and white pilgrim's bottle-shaped porcelain vase, which was produced during the late Ming dynasty (1368–1643). It is decorated with the historical event of the loyal General Kuan Yu of the Three Kingdoms of the Minor Han dynasty (222–264), later worshipped as the God of War. Kuan Yu is riding a horse and is fighting with General Chou Yu of the Wu Kingdom. This vase has a fine porcelain body molded with a high foot and a long cylindrical neck; two lizards (emblems of chastity) in high relief at the shoulders serve as handles. The design of the sacred lotus flower appears on the narrow sides with the key fret pattern and clusters of buds below the mouth.

FIG. 20.—Ko Yao vase with ox-blood decoration, K'ang Hsi period; about 22 in. high.

FIG. 21.—Apple-green vase, K'ang Hsi period; $5^1/_4$ in. high.

Cobalt blue underglaze covers the entire vase. (See also Fig. 23 and its description, pp. 206 and 207.)

(4) Chinese Customs

This kind of symbolism is not necessarily recorded in history or literature, but it is based on common belief from remote time to the present. The bat, which has the body of an animal and the wings of a bird, is called by the Chinese "Fu," and the character for happiness is also called "Fu"; the bat and happiness, therefore, are synonymous. It is often depicted in Chinese porcelain, sometimes with five bats, which mean five kinds of happiness, and sometimes with one hundred bats.

There was a lady in ancient times who went to the moon and was called "Hsiang Wo." When the Chinese say that a girl is like "Hsiang Wo," it means that she is the most beautiful girl in the world. The picture of an old lady combing her hair in the shape of an acorn and with her weaving equipment near to her is always the portrait of the Empress of the Yellow Emperor (2697–2597 B.C.), so-called because she invented the culture of the silkworm and the weaving of the silk.

Many fairy stories, not recorded in history but often mentioned in novels, are also used in decorations. The scenery of T'ung Huang Chun, King of the Eastern Region, welcoming Hsi Wang Mu, Queen of the Western Region, is popular in decoration.

Everywhere in the world, in ancient or modern times, people want to become rich quickly, so the story of Liu Hai is suitable for such a thought. Liu Hai went fishing, but instead of getting fish he got some coins which signifies he had become rich. There are many of these interesting stories.

III. Conclusions

Symbolism in Chinese porcelains began in the Sung period and extended to the Ch'ien Lung period. These pieces are very important and rare. Figure 16 shows a Chün Yao tripod of the Sung dynasty. It has a broad porcelain body with tapering shoulders to an expanded mouth and three legs, which is identical with the form of an ancient "Ting," cauldron. It is covered with Chün Yao glaze and crackled; there is also a peculiar wheel-

FIG. 22.—Lang Yao and apple-green vase, K'ang Hsi period; $10^{3}/_{4}$ in. high.

FIG. 23.—Decorated porcelain vase, K'ang Hsi period; $17^{5}/_{8}$ in. high.

mark resembling a spiral shell. This specimen, which is extremely rare, came from Prince Ch'ing's collection.

A Chien Yao bowl, shown in Fig. 17, is commonly known in this country as temmoku ware. It is also of the Sung period (959–1278) and is coated with a heavy black glaze in the texture of hare's fur and crackled. It was found at the bottom of the Min River with the shells attached. The bowl has a specially carved stand to harmonize with its structure. It bears historical significance regarding the tradition of Chien Yao bowls, which were greatly admired by the Chinese scholars of the Sung House when they assembled to sip tea.

Figure 18 shows a five-colored enamel decorated porcelain vase, made during the reign of Emperor Wan Li (1573–1619) of the Ming dynasty. The border around the rim is decorated with stiff plantain leaves. Just below the rim of the mouth is the six-character reign mark, "Ta Ming Wan Li Nien Chih," meaning that it was made during the reigning years of the Emperor Wan Li of the great Ming dynasty. The first decoration on the neck is the dragon floating on auspicious clouds below which are flowers and then another dragon. The peony and phoenix designs are on the body of the vase with the key fret and Ju-I (as you wish) designs above and the baluster design below. In the lower part is the Rock of Ten Thousand Ages in the wave design. This vase, at present, is extremely rare.

An iron-dust porcelain bowl of the Ming dynasty (1368–1643) is shown in Fig. 19. The exterior and interior are invested with iron-dust glaze and decorated with white slip in the design of prunus flowers in full bloom, ascending and descending, on the exterior and interior.

Two of the K'ang Hsi porcelains were originally in the Imperial Collection and came from the Gallery of the Famous Ten Porcelains. Figure 20 is a Ko Yao porcelain vase with ox-blood decoration; it has a bulb-shaped body with a straight neck to the mouth, and it is decorated with a floral design and crackled on biscuit. It is a very rare specimen in monochrome of Ko Yao color as a background with ox-blood decoration.

Figure 21 shows an apple-green vase made during the K'ang Hsi period (1662–1723). It has a fine porcelain body which the Chinese designate as an olive-shaped bottle. The interior, exterior, and sunken base are crackled; the exterior is invested with a brilliant apple-green glaze; it has a special iron foot like those used by the Sung potters. This is an exceptional specimen.

Figure 22 shows the famous Lang Yao and apple-green vase, which is pear-shaped and was made during the K'ang Hsi period. The body is of porcelain with a wide mouth, a high neck, and a slightly high foot. The combination of glazes is its most characteristic feature. The lower part is the Lang Yao glaze, and the upper part is apple green. Crackle on biscuit, both inside and out, covers the entire vase. Its exact coloring, the Lang Yao glaze, cannot be expressed in words. Lang was the surname of the vice-governor, whose official name was Ting-Chi and who was appointed to the post of vice-governorship of Kiangsi Province from the forty-fourth to the fifty-first years of the Emperor K'ang Hsi (1705–1712). Vice-Governor Lang was also the director of the imperial factory at Ching-tê Chên during that period. He was credited with the invention of Lang Yao ware, especially ware with the red coloring.

It is said that only two pieces of such ware were made during the K'ang Hsi period, but no trace has been found of the other one. This piece, therefore, is the only one known in existence.

Figure 23 is another example of a symbol derived from a historical source (see Section (3), p. 205). A decorated porcelain vase of the K'ang Hsi period is shown; the fine porcelain body is molded in a cylindrical shape with a slight tapering from the body to the foot. It is skillfully decorated in colored enamels which depict a battle scene of ancient historical origin at the city of Yen Kê where the enemy generals were captured and killed. The display of the battle scene with the human figure, flowers, landscape, and trees is magnificiently arranged. The most unusual workmanship is the coloring, known as "enamel on biscuit" by the Chinese potters. The green glaze shows its strength, as do all the works of that period. The shoulder has four medallions, which are decorated with books, a vase, water coupes, a sword, and daggers.

NOTE: Dr. Chen was head of the Chinese Classics Department, Hwa Nan College, Foochow, China, 1912–1920, and instructor of Chinese literature and language, Johns Hopkins University, 1920–1925.

339 EAST 29TH STREET
BALTIMORE, MARYLAND

THE EFFECT OF SLOTS

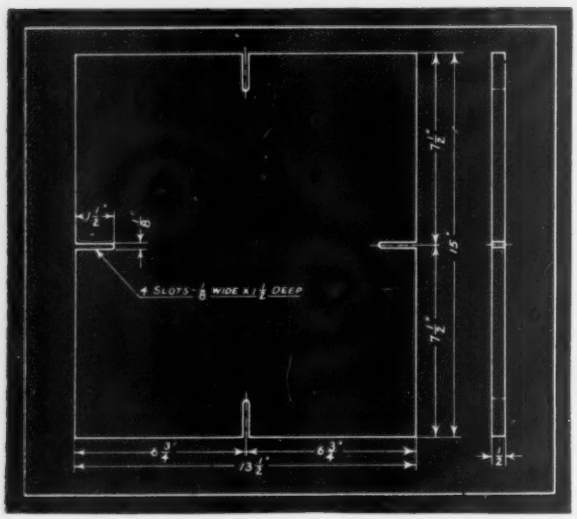
IN REFRACTORY CRYSTALON RECTANGULAR BATTS

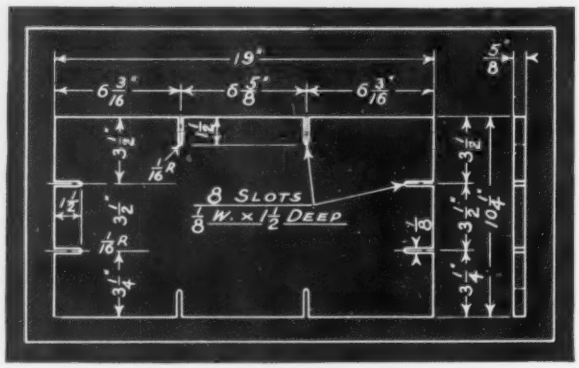
THE use by the ceramic industry of continuous kilns has necessitated the development of special refractory kiln furniture and car tops. Those items of kiln furniture most affected have been batts, saggers and supports.

The operating cycles of continuous kilns differ markedly from kiln to kiln depending upon the product being heat treated or fired. Some kilns run on cycles as rapid as 24 hours and others run on cycles as relatively slow as ten days.

Large amounts of kiln furniture, like batts, saggers and supports, travel through these kilns and are subject to the various temperature conditions for longer or shorter periods. Refractory materials are called upon to withstand many different conditions, but generally speaking, the hardest condition to be met is that of temperature differential.

Within the setting on any kiln, car stresses are set up which are caused by the method of applying the heat. That is to say, heat is applied at right angles to the setting at the outer edge and until a condition of equilibrium is reached, stresses are set up in the setting because of temperature differentials.





During the heating up period the outside of the setting is hotter than the center and will expand more rapidly resulting in a conflict of stresses; i.e., compression at the outside and tension at the center. During the soaking period, when temperatures are uniform, the stress-strain conditions in the setting disappear.

During the cooling period the stress-strain conditions re-appear in the reverse order; i.e., tension at the outside of the car and compression at the center.

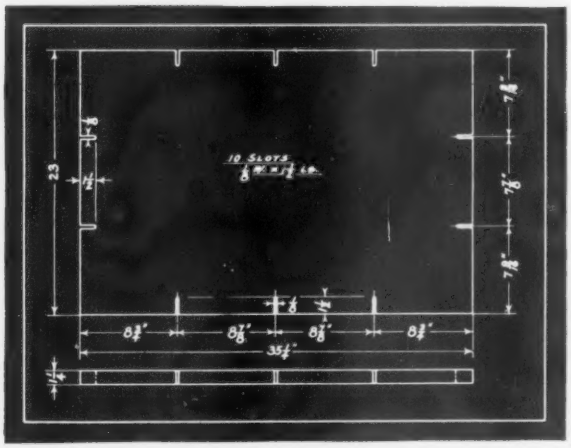
Whether or not the refractories will crack depends upon the magnitude of the stresses set up. To relieve by mechanical means the stresses set up in the batts and to mitigate the severity of the effects of rapid heating and cooling, Norton Company developed the Slotted Batt.

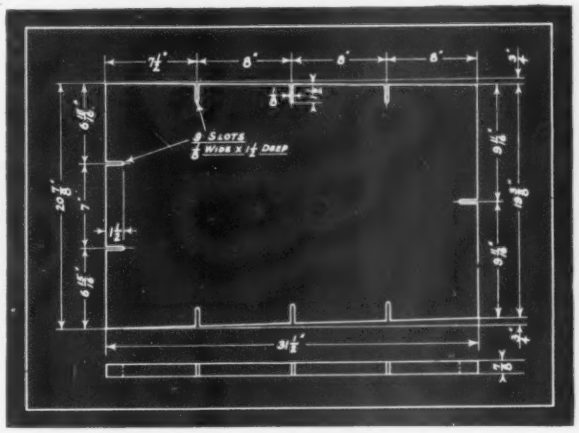
Illustrated on these pages are a few typical sizes and shapes of slotted batts.

These CRYSTOLON batts may be described as plates or tile of refractory CRYSTOLON (silicon carbide) material having openings or slots which extend inwardly from the edge to compensate for expansion and contraction of the tile due to thermal changes when in use. Some of these batts have a series of openings. Whether there be one or more openings to a single edge is largely determined by the length of that edge.

Increased life on the part of slotted batts has been proved both in the laboratory and in actual service. The reasons behind the success of slotted batts are relatively simple. When a rectangular or circular body is heated around the edges in the case of a rectangular piece and around the periphery in the case of a circular piece, the article tends to expand and become larger in the outer zone where the heat is applied. The central zone being cooler does not expand at the same rate, hence we have the outer zone tending to expand and the central zone holding expansion back. Consequently, a point is reached where breakage occurs. According to photoelastic results obtained when heating bricks (Prof. F. H. Norton, M. I. T.) the central area under tensional stress takes a circular or elliptical form.

Accordingly, therefore, if we take a rectangular batt with no slots and put in each side of this batt slots of such a depth that when the batt is heated the base of the slot is approximately at the neutral axis of the stress then we can expect this batt when heated to breaking point to have withstood greater heating than would be the case with a batt having no slots at all. This could be expected since by adding the slots the maximum sheer or compressive stress would be reduced and thus the batt would withstand more severe temperature differentials.





Since the function of the slot is to relieve thermal strains by mechanical means, we may assume that the greater the number of slots in the side of a given batt, the more rapidly the batt may be heated or cooled without cracks developing. Aside from theoretical consideration, there is a practical limit to the number of slots which may be used. Mechanical strength of the batt must be maintained, and as much of the batt surface must be available for setting ware as it is possible to attain. Therefore, the number of slots must for practical reasons be kept to a minimum, consistent with the attainment of a reasonable degree of freedom from cracking.

The results from many experimental and practical trials lead to the following conclusions:

1. That a batt with one slot per side will withstand about twice the heating (constant rate of heating) that a batt with no slots per side will stand.

2. That a batt with two slots per side, said slots dividing the sides of the batt into thirds, will withstand about three times the heating (constant rate of heating) that a batt with no slots per side will stand.

NORTON RESEARCH

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CERAMIC HISTORY

SAMUEL POLLOCK HARBISON

Samuel Pollock Harbison was born in 1840 in Bakerstown, Allegheny County, Pennsylvania, where he received his early education. He died in Pittsburgh in 1905. His parents on both sides were of sturdy Scotch-Irish descent and were Covenanters and most exemplary Christians. All of their antecedents were Presbyterian as far as known, and the families still continue in that communion. The Harbisons came to this country about 1756; they located first in Sherman Valley, crossed later to Westmoreland, and then to Butler County. The Pollocks (or Polks) probably came at an earlier date, settling in Washington and Lawrence counties and in Tennessee.

Mr. Harbison's early life at home had in its discipline just those elements that serve to develop the best in any nature. He has said oftentimes that he was glad he had been reared in the simplicity and toilsomeness of country life, for it made him think for himself and engendered a strong desire to broaden his horizon.

His love of business early manifested itself, and when other boys would be playing or off with a gun, he was carrying on a miniature tannery or other line of manufactory, such as he was familiar with in his neighborhood. Later, when he came to the crucial time of deciding for a profession or for business, he had little difficulty, for all his predilections were for the latter career.

That he did not enter the ministry was often a subject of inquiry by his friends. He invariably answered that he never felt himself to have any of the qualifications for that sacred calling other than the desire to serve God and that he felt he could do as well in a business life as in the ministry. While quite a small lad, with his brothers and sisters, he was always expected to be ready for the call of the pastor, who then made regular visits on his people to catechize the children. It was always a pleasure for him to recall this as well as the drill of the village singing teacher, who found several voices in the Harbison home worth cultivating.

Letter from S. P. Harbison to His Sons

The following letter from Mr. Harbison to his sons gives an account of the early beginning of the Harbison-Walker Refractories Company:

Allegheny City, Pa.,
Oct. 19, 1900

My beloved sons:

In compliance with your oft-repeated request that I give you some little history of my connection with the brick business, I will endeavor now to do so, but will give you a short account of my previous work.

In the summer of 1856, in my sixteenth year, I left home in Bakerstown, Pa., to attend the Normal School conducted by Mr. B. M. Kerr, then County Superintendent at Mansfield, Pa. At the close of this term, I received from him a certificate qualifying me to teach in the public schools; and in the autumn of 1856 I secured my first school in Pine Township, known as M'Cord's, beginning Nov. 1, for which I received a salary of $22 per month. At the close of this term, indeed the last day of school, I found myself very ill, and it resulted in a long attack of typhoid fever.

Late in the summer, I obtained employment in the store of James Ross in Bakerstown, where I spent the rest of that season, and in the fall of 1857 I secured a school in Pine Township, a little nearer home, known as the Crawford school; and the following summer, in 1858, attended the Normal School in Bakerstown.

The winter of 1858 and 1859 again found me in the school in which I had taught the previous winter, and the summer of 1859 I spent at Jefferson College at Cannonsburg, in the preparatory department, returning in the fall to take up my work for the third term in Crawford's school of Pine Township.

The summer of 1860 I spent at Ellersridge Academy in Armstrong County. In the fall of 1860 I began teaching in Collin's School on the Washington Pike in South Fayette Township, remaining there until July 1, 1861. In September of 1861, my next school was known as Olds' School, near M'Clure Township, now part of the 11th Ward Allegheny. I remained there until about December of 1862 when I was elected to the principalship of the Minersville School, now part of Pittsburgh, which position I held until the spring of 1864 when I accepted an appointment as Cashier in the Clerk of Court's office, under Col. William A. Herron, then Clerk of Court.

I remained with him until the close of the year 1864 when I secured a position with the Pittsburgh Glass Manufacturing Company, purchasing an interest in it through money provided by Mr. Andrew Carnegie and Mr. Henry Phipps, Jr., my friends of early days. This business did not prove very satisfactory owing to the troublesome character of the Manager of the Works, and my friends thought it best to close out my interest there, which was done, and in the Spring of 1865 I accepted a position with Joseph Myers, the Jew cattle dealer of Allegheny, as clerk, and spent the next year and a half in his employ, winding up a very large business which he had conducted with the Government during the war, in furnishing beef to the army. A part of the winter of 1865 and 1866 I spent in Baltimore, the headquarters for this business, and where final settlement was made with all of the partners.

First Connection with Firebrick Business

On the first of May, 1866, I engaged with the Star Fire Brick Company, which had been organized the year previous, to give half my time in its service and the other half of my time to that of Mr. Myers, who with ten other gentlemen constituted the stockholders of the Star Fire Brick Company. The works had been built during the summer of 1865, and the first sale of brick was made on Sept. 26, 1865, being my birthday. The Company had been organized by Mr. J. K. Lemon, who secured six stockholders,

the capital in the aggregate being only $8000, but a few months afterwards it was increased to $16,000.

As Mr. Myers' bookkeeper, I was engaged to open up the books for the Company at night, and on the first of May, 1866, I was engaged to give half my time to this service, the Company allowing me $100 for the work I had done the previous winter in putting their accounts into shape. My salary for half time was $50.00 per month until the 1st of June, 1867, when it was increased to $800 per year for half time.

My first interest in the Company was the purchase of five shares from Robert Kingan, who owned five shares of the par value, $500, but the loss in operating the first six months had reduced the value of this stock to $368.97, and it was at this figure I purchased the five shares, thus beginning my first interest in the Company as a stockholder. This purchase was made in the Spring of 1866. Other small interests were secured from time to time, as I was able to pay for them from my salary.

This business, after the first year's loss, began to prosper in a very limited way, but still the stockholders in the Company were dissatisfied, and most of them were very anxious to get rid of their stock; as the Company was not chartered, they were individually liable and were afraid that they might be involved in greater obligation, so that in the course of a few years most of them had retired from the Company, selling out their stock at par value.

The business went along with Mr. Lemon as Manager and Superintendent of the business, with myself as bookkeeper, giving half my time to its service until the summer of 1870. I had by this time become familiar with the business and had learned the nature of clays sufficiently to feel that I could undertake the running of the works myself. . . . .It resulted in a meeting being called for the afternoon of August 29, 1870, in the office of the Allegheny Trust Company, on the Diamond, in Allegheny. At this meeting, Mr. Lemon and the other stockholders of the Company were present when a resolution was offered by previous understanding by Mr. Joseph Myers, as follows: "Resolved, that S. P. Harbison be employed as General Manager of the Company, at a salary of $1500 per annum; he to have full power to employ such help as he needs to carry on the business successfully, and to discharge any person or persons who in his opinion can be replaced at a lower salary." This resolution was adopted unanimously. . . . .

The next day . . . . I announced . . . . that, in accordance with the resolution that had been passed the previous day, I had decided to take hold of the works and assume all responsibility for running them . . . . . Mr. Lemon offered to sell his stock in the Company, which amounted to $3000 of the $16,000 capital. This I took off his hands at once, thus relieving Mr. Lemon of all his interest in the Company.

The Articles of Association that had been entered into on March 7, 1865, were for the term of ten (10) years from that date. During these ten years, the operations were as follows:

	Net loss
First settlement, Spring, 1866	$ 2,096.48
	Gain
January 1, 1868	2,051.14
December 31, 1868	5,464.22
April 1, 1870	8,461.08
April 1, 1871	8,909.09
April 1, 1872	8,266.41
Jan. 1, 1873	18,561.01
April 1, 1873	3,231.83
March 31, 1874	8,030.58
June 28, 1876	2,007.44

On the same date, in winding up the business of the Company, there was a credit to profit and loss of $8,007.86, making a total of earnings and receipts from the winding up of the business of $72,990.66. Out of this was paid in cash dividends the sum of $50,189.68 from time to time, beginning with February 1, 1870, when the first dividend of 20% was declared; to cover the loss sustained in first year's operations $2,096.48 and to wipe out the Construction Account, the amount expended in the construction of improvements, the sum of $20,704.50. Thus in the ten years' existence of the Company with a capital of $16,000 there was returned a net sum of $50,189.68, as the result of its operations.

The stockholders in the Company when it wound up were W. A. Reed, President, Allegheny Trust Co., $6000; W. J. Kountz, $3000; and S. P. Harbison, $7000. The first sale recorded in the books of the Star Fire Brick Company was September 26, 1865, "sold to Zug & Co. 1350 firebrick at $40 per M." The last sale recorded by the old Company was on August 31, 1874, to the firm of Kloman & Carnegie Brothers.

The lease on which our works were built expired at the end of the ten years, and the year previous Mr. Reed and myself bought the property across the railroad from the site of the original works and we organized the new firm of Reed & Harbison, taking over all the old material that could be used in the construction of the new works, thus enabling the old Company to wind up with the least possible loss. Mr. Reed was enabled, owing to his position in the bank, to secure for us all the money necessary to construct the new works on the new site, and all was going along very smoothly when the failure of the Allegheny Trust Company caused him to suspend, and the financial affairs of the new Company then became very seriously involved, it being a question whether we would not have to speedily close the business as the money we had borrowed on accommodation notes in the Allegheny Trust Company were soon due and my credit was not sufficient to secure other accommodations.

Organization of Harbison & Walker

At this time, early in the year, in January of 1875, Mr. Hay Walker, the father of my present partners in the business, was induced to purchase the interest of Mr. Reed, Mr. Walker and myself each having one-half interest in the Company then organized under the name of Harbison & Walker, under which name the business continued for a number of years, until the present corporation was organized in 1902. (On the death of Mr. Walker, the interest was taken in the name of his son, Hepburn.)

A few years after Mr. Hepburn Walker had become my partner, I became anxious to have more liberty and freedom, not being able to give as much energy to the business as in previous years, and proposed to him that I would be willing to reduce my interest from one half to one third on an equitable basis, if his brother, S. C., would leave the pork business in which he was engaged and come in with

us and give his time to the business. This proposition was very agreeable to Mr. Walker and the arrangement was speedily consummated. The partners were then the two brothers and myself, until the death of Mr. Hepburn Walker, when the other brothers, Hay and William, together with S. C., took the two-thirds interest in the firm, one-third being in my name, and thus it continued until the present Corporation was organized.

It is not my purpose in this to give an extended account of the firm "The Harbison & Walker Company" as my relations in this Company are simply that of a stockholder and as I have not been giving my time to it in an official capacity.

After my engagement with the Company in the spring of 1866 in giving one half of my time to its service, I began canvassing the mills and factories around the City, soliciting their trade. By very hard work and a great deal of persistency, I would secure trial orders only too often to result in the brick being condemned. It might be well to say that Mr. Lemon, who organized the Company and managed all its affairs at the time, had had no practical experience in the manufacture of firebrick and knew just as little about fire clays, so that the manufacturing of brick up to this time had been purely chance work. His trade prior to this had been that of a brick layer, or brick mason. The material they were using at this time came from mines up in the vicinity of Bolivar and needed very close inspection to keep it free from iron ore which was found very largely in all the clay mines in that vicinity. One of the proprietors of a rolling mill near by, seeing the pile of iron ore we had rejected from our clay, jokingly asked us if we were going to build a blast furnace. Frequently whole kilns of brick would be turned out and found so defective that it was unsafe to put them on the market.

For five years we continued to experiment, meeting occasionally with a fair degree of success, but very frequently finding brick that we had urged upon customers as being thoroughly reliable prove to be very defective when put to the test in the furnace. I was naturally of a diffident, retiring disposition, and you can understand how difficult it was for me to keep up the fight and solicit trade in the face of so many repeated failures

In the course of the five years, or up to the time when I took charge of the works, I had become pretty thoroughly familiar with clays and with the process of manufacturing, and felt myself competent to take charge of the works and release Mr. Lemon from any further relation to the Company. I then began making more extensive canvasses, going out frequently through the Mahoning and Shenango Valleys, working to secure blast-furnace trade, which up to this time had not been touched by us, confining ourselves almost entirely to the rolling-mill trade.

We secured a few small orders, the first one, I believe, being from James Wood Sons & Co., Wheatland, Pa., where we had a very fair measure of success, and were thus in a measure introduced into the business when Kloman, Carnegie, & Company built their first Lucy furnace. We had at this time secured a very satisfactory trade with this Company in their rolling mill and made a very strong fight to secure the order for their new furnace lining. I was determined to have this even though we should take it at actual cost, as I realized it was a new departure in the way of modern furnace building. This lining happily turned out very good, lasting during a period of three years and producing 75,000 tons of iron, the largest that had ever been known up to that day. I secured a letter from Mr. Thomas M. Carnegie, giving the results of this blast, and had a sketch made of the furnace, showing just how much wear there had been on the lining during that period and giving a short history of the blast in connection with Mr. Carnegie's letter. These we sent broadcast to the blast-furnace trade, which at once secured for us a hearing by every blast-furnace man in the country. We soon began receiving orders, and from that time on, the manufacture of blast-furnace linings was one of our leading specialties. It has been so up until the present time.

. . . . . .

I would not be entirely faithful if I did not say to you that in all the developments of this Company's affairs I was conscious that personally I was favored of the Lord in whose service I had always been engaged. It was a very common thing for me on my return from a tour of soliciting to look back over the success and prosperity that had been given me on the trip, in seeing those whom I had sought to interview and whose favor I sought to secure, and to recognize that the Lord had very graciously guided every step; and my habit on my return to my room where I was then boarding as a single man was to thank the Lord for all the way I had been led and cared for. It has been my privilege to recognize His good hand upon me in all my business life, and I today can only praise Him for the gracious, kindly providence that has been about me in my business relations, especially in giving me the kind of men with whom I have been associated in all these years, who have only had one purpose ever before them, to do a thoroughly honest business, priding themselves always on producing the very best article that could be made and dealing with the utmost honesty and frankness with our customers. The happy result for the long period of work of this kind is seen today in the favor given us and the preference that in nearly every case is allowed us in the trade, and I rejoice to believe that the spirit that has actuated the business of this concern from its inception until the present day will still continue under those who are now in charge of its affairs.

Hoping that the above very short and very concise account of the Company may meet with your wishes, I am

Your very affectionate Father,

SAMUEL P. HARBISON

Personal and Religious Life

With his very first earnings, he began systematic giving and keeping a strict account of all expenses, a habit which grew with the years, and as his means increased, so did the love of distribution, until, from a tenth, he gave his entire income outside his living expenses. He never pursued money as an object and always accepted prosperity as a direct gift from God. Indeed, the question of stewardship was to him a very vital one, and one by which he was used to help many who had never known the joy of Christian giving. The following extract from his will shows his earnestness in this:

"I have no provision in my will for any charitable bequests, as I have, during my life, administered largely on

my own estate and have, from year to year, given to the Lord's work and other charities, as though it were my last. This course I expect to pursue so long as I may live. In leaving my estate to my family, it is my hope that they may act upon the same principle, remembering that the 'King's business requires haste,' and that what we do for Him ought to be done quickly, so that, should He come in my time or in your time, we be not found with His money in our hands that ought to be out doing service in His cause."

He loved to teach, and he had a rare gift in making his scholars enjoy their work, and many have told him of their delight in grammar as he taught it. And then, as a teacher of the Bible his thoroughness and clearness, as well as his profound reverence, never failed to elicit the most careful attention.

He loved young men and never denied them audience, and little children knew he was their friend. Often a baby would reach its little arms to him that had turned away from others who had similarly approached it. His filial devotion to his aged mother, who held an honored place in his home for fourteen years, and, indeed, his almost reverence for all elderly persons was a very prominent characteristic. It was hard for him to realize as he grew older that the time had come for him to receive the courtesies his age might expect, instead of ever being on the alert to make way for others.

He was a wise counsellor. Possessed of unusual gifts of mind as well as of heart, his word of advice was always sought with eager desire.

While Mr. Harbison was a man of intense practicality, while he had one of the keenest intellects, while he seized the truth and held it with an unfaltering grasp, he was a man of the most tender emotions. His heart, as well as head and hand, went out to mankind everywhere.

In judgment, he was not only wise, but most just and honest. He examined all questions from every point of view and weighed them with the minutest care. He was thoroughly free from prejudice, and when he detected an error in his conclusions, he was prompt to correct it. The fact that he reached a certain conclusion on a given matter at a certain time did not suffice for that same question at another time. But upon its reappearance, the question was fully reviewed and re-examined. His justice, accuracy, and honesty in forming a judgment was one of the ever-present and permanent traits of this good man.

From the beginning of his business life, he devoted himself, not simply to making a fortune, but far more intensely to building up a character.

This short sketch of the life of Samuel Pollock Harbison may well close with the following statement taken from the minutes of the Harbison-Walker Refractories Company of May 18, 1905.

"His talents were of wide range, and whether used in the business of the Company, in financial circles, or in benevolent work, the same energy, courage, and firmness of character were manifest.

"Throughout his long and honorable career, he was known particularly by his consistent Christian life, which found expression not only in the use of his means for the welfare and improvement of those most in need of them, but also in encouraging both his associates and employees in aiming for an upright and honorable life."

HISTORY OF DEVELOPMENT OF THE REFRACTORIES INDUSTRY IN THE UNITED STATES

By Arthur F. Greaves-Walker

I. Introduction

Except for those persons directly interested as producers or consumers, few realize the importance of the refractories industry to modern civilization. The progress of the mechanized world as it exists today has been largely dependent on it. The present development in railroads, motorcars, electric light and power, radios, concrete or brick highways, and many of the comforts found in the average modern home would have been impossible without it. The extent of the dependence of all other industries on it may be judged from the fact that at the bases of the myriad of chimneys that poke their tops into the sky in every industrial district are thousands of refractory brick and shapes lining the furnaces in which heat is generated for one purpose or another.

II. Refractories Defined

In the sense in which the term is used in this history, "refractories" designates products usually manufactured from nonmetallic minerals and rocks coming within the classification of ceramic materials and used for heat-resisting purposes. There are some high-temperature or heat-resisting metallic alloys used for furnace linings and crucibles, but they are not classified as refractories.

(1941)

III. History

The history of the refractories industry in the United States parallels that of industrial development. Industry had its beginnings in this country in New England and northern New Jersey, and it is in those sections that the first refractories plants were established. As industry traveled westward through Pennsylvania to the Ohio Valley, the manufacture of refractories followed it step by step. Illinois, Missouri, Colorado, Montana, Utah, California, Alabama, and Washington became centers of refractories manufacture as the population moved west and south, carrying industry with it.

Whether materials suitable for the manufacture of refractory products happened to be available near the large industrial centers being developed or whether these centers developed to a considerable extent because of the proximity of deposits of refractory materials, the fact remains that the largest centers of industry have close by large reserves of such materials from which to draw.

IV. Early Furnace Linings

Although stone was used for linings in the early glass and iron furnaces, kilns, and forges, comparatively few stones are suitable for this purpose. Where stone was not easily

available, it was natural that a suitable clay should be sought from which brick or shapes could be made.

V. First Fire-Clay Refractories

The location where the first refractories in the United States were made will probably always remain in doubt, but acceptable evidence appears to point strongly to Florida. A short distance south of Daytona, near New Smyrna, are the ruins of a sugar mill built by the Spaniards and said by local investigators to date back to about 1600. St. Augustine became a permanent settlement in 1565, and the land along the coast as far south as New Smyrna was the first to be settled and cleared. It is quite within the realm of possibility therefore that the small mill should have been built in about 1600 to take care of the cane which was one of the principal crops of the early Spanish settlers.

The ruins of this mill are well preserved, especially the furnaces beneath the cauldrons. The firebrick used were made of kaolin contaminated with surface material. Because large deposits of similar material are located some miles to the west of the plant site, there can be little question about its origin. The brick are very rough and evidently were made by unskilled labor, but they are strong and show no effect of the comparatively low temperatures to which they were subjected. Centuries of weathering have not affected them.

One of the earliest uses of refractories in this country was undoubtedly at Jamestown, Virginia. On instructions from the London Company, a glass plant was built there in 1609. As neither refractory clays nor suitable stone was available near Jamestown and as the colonists did not dare venture far inland, the materials necessary for glass pots and the refractories for the pot furnaces were probably brought from England.

(1) New England

New England manufacturers who required refractories before the Revolutionary War apparently relied on local stone or firebrick imported from England, but the war forced them to look about for suitable clays. When refractories manufacture did begin, the consumers directly interested made their own products. Thus the records of the early glass manufacturers contain references to imported glass-pot clays from which they made their own pots.*[1]

The earliest available reference to firebrick manufacture is to the Boston Manufacturing Company which employed men to make and to fire brick and tile for furnace linings in 1790 and 1791.[1] The fire clay used was evidently shipped from New Jersey.

In 1827, Denning Jarves of the New England Glass Bottle Works, Boston, advertised that he made for sale firebrick to all dimensions.[1] At this date, the records show considerable fire clay being shipped from New Jersey to Boston.

The kaolins of Connecticut were used to some extent for refractories during this period. Crucibles for melting metal were made of Connecticut kaolin as early as 1807. In 1829, L. Hine[1] was using it at New Milford, Connecticut, to make firebrick. In 1839, L. Norton of Bennington, Vermont, erected a plant to manufacture firebrick made of a mixture of local kaolin, calcined kaolin, and ground quartz.[2] These brick were said to have stood up well in the hearths of iron blast furnaces. Another plant in Bennington advertised the manufacture and sale of "patent firebrick" in 1841; the price was $50.00 per thousand.[1] In 1846, a plant located at Monkton, Vermont, made firebrick of a mixture of local kaolin, New Jersey fire clay, crushed firebrick, and sandstone.[1]

A number of other refractories plants were scattered throughout New England during this period and for some years afterward, principally in or near Boston, but most of them were small. They gradually disappeared, however, as the refractories industry grew in New Jersey, and the tide of the consuming industries moved south and west.

(2) New Jersey

The excellent plastic fire clays of New Jersey must have been discovered by the colonists at an early date, and they formed the basis of the first extensive manufacture of refractories in the United States. The clays apparently were mined and shipped to New England for many years before their manufacture into refractories began in New Jersey.

The first plant of which there is a record is the Salamander Works at Woodbridge,[2] which was operating in 1825. The J. R. Watson plant at Perth Amboy followed in 1833.[2] The Berry and Son plant at Woodbridge commenced operations in 1845; the Maurer and Son plant at Maurer, in 1856; M. D. Valentine and Bros. at Woodbridge, in 1865; and Sayre and Fisher, Sayreville, in 1868.[2] Other small operations probably existed during this period, but they have not been recorded so far as is known.

(3) Delaware

Available records indicate that kaolin was mined in Delaware as early as 1800, and it was sold for the manufacture of crucibles, glass pots, and (possibly) firebrick.[1]

(4) Pennsylvania

This State, which now ranks first in the production of refractories, apparently started manufacturing for the trade before 1832. In that year, the American China Manufactury, Philadelphia, advertised firebrick for sale[1]; and A. Miller, also of Philadelphia, was manufacturing firebrick in 1840,[1] and the fire clay probably was shipped from New Jersey.

During the 1830's, the high-grade fire clays of central and western Pennsylvania were discovered, and the foundation was laid for the State's present leadership.

A plant, later operated by Fredericks, Monroe, & Co., was started in 1836 at Queen's Run. Following this, plants were built by S. Barnes & Co. at Rochester in 1839; James Glover at Bolivar, in 1842; Kier Bros. at Salina, in 1845; Soissons and Co. at Connellsville, in 1859; and the Star Fire Brick Works began operations near Pittsburgh in 1865.[2]

A plant for manufacturing glass pots was started by Thomas Coffin at Pittsburgh in 1860.

(5) Virginia (West Virginia)

The fact that fire-clay refractories were manufactured in that section of Virginia which is now West Virginia at least as early as in Pennsylvania and earlier than in Mary-

* For references, see Bibliography, p. 216.

land has not been generally noted. Records show[3] that fire clay was shipped from the mouth of Holvert's Run, near New Cumberland, to Pittsburgh in 1830. In 1831, Thomas Freeman erected the first firebrick plant at New Cumberland, and several other plants were built in this section within the next twelve years.

In 1837, the firebrick output of the New Cumberland district was 200,000; in 1844, it had jumped to 1,500,000; and in 1872, it reached 11,000,000, in addition to 12,000 tons of fire clay shipped to points on the Ohio River.[4]

(6) Maryland

Firebrick were made in Baltimore as early as 1831, but Maryland first established a reputation as a producer of refractories when the Union Mining Company erected a firebrick plant at Mount Savage in 1837.[2] The refractories made at this plant were, for more than fifty years, considered equal to the world's best.

(7) Ohio

Although firebrick manufacture was reported at Toronto, Ohio, as early as 1830,[2] the first authentic record of production in the State gives credit to the plant of Andrew Russell near East Liverpool in 1841.[5] About 1852, G. and M. Meyers were operating a plant at Toronto. Firebrick were produced in Steubenville in 1854. In 1863, R. Thomas manufactured the first flint-clay brick, in Scioto County; and the Diamond Fire Brick Company, under the direction of J. P. Alexander in 1866, began operations at Akron. In 1868, a three-kiln firebrick plant was built at Dover; and C. E. Holden established the Federal Clay Products Company at Mineral City in 1872.

(8) Missouri

The manufacture of refractories began in Missouri in a plant located in St. Louis in 1846, but the name of the owner is not known.[2]

The Evens and Howard and the Laclede Fire Brick companies established plants in 1855; the Christy Fire Clay Company began operations in 1857; and the Parker-Russell Mining and Manufacturing Company, in 1866, all in St. Louis.[2]

In the early 1900's, the first refractories plant was erected on the now famous Bevier fire-clay deposits by the Mexico Brick and Fire Clay Company at Mexico, Missouri. This plant was purchased in 1910 by A. P. Green, one of the pioneers of the modern refractories industry, who received his engineering training at the Missouri School of Mines. A few years later the firm name was changed to the A. P. Green Fire Brick Company.

(9) Georgia

Firebrick were made from refractory kaolins by Henry Stevens and his two sons, W. C. and J. H. Stevens, at Stevens Pottery, Georgia, in 1861. This Company, as far as is known, was the first to use the southern refractory kaolins. The Stevens Pottery plant, which has been in continuous operation since its establishment, is now a unit of the General Refractories Company.

(10) California

The first firebrick were produced in California at Lincoln, Placer County, in 1875. The producing company was organized by Charles Gladding, Peter McGill McBean, and George R. Chambers, all of Chicago.[6]

The first firebrick in the southern section of the State were produced at the Dolbeer plant in Los Angeles in 1880 by John Barnes. The fire clay used was shipped from Elsinore.[7]

(11) Colorado

In 1876, J. O. Bosworth, assisted by E. E. Burlingame, started the experimental production of refractory assay goods. In 1880, the Denver Fire Clay Company was incorporated, and a plant was built at Denver during this time. The production of firebrick began in this plant about 1880.

In the late 1880's, the Standard Fire Brick Company began the manufacture of firebrick at Pueblo.

(12) Montana

The first plant for the manufacture of firebrick in this State was constructed at Anaconda by the Anaconda Copper Company in 1885. The output has always been used by the Anaconda Company in its own operations.

(13) Kentucky

Kentucky joined the list of states manufacturing refractories in 1886 when the Ashland Fire Brick Company built a plant at Ashland. The Louisville Fire Brick Company built a plant at Louisville in 1889, and the old Clinton Fire Brick Company plant, now owned by the Ashland Fire Brick Company, was constructed at Ashland in 1890.[2] All of these plants used fire clays from the Olive Hill district.

In 1895, Hoblitzelle and Hitchins of Frostburg, Maryland, established the first plant in the Olive Hill district at Olive Hill. This partnership became the Olive Hill Fire Brick Company, and the plant later became one of the original units of the General Refractories Company.

The establishment of this plant at Olive Hill was followed by another constructed by the Harbison-Walker Refractories Company in the same town as well as a number of other plants at points in Carter, Rowan, and Lewis counties.

Havard[2] states that fire clay was shipped from Lewis County to Cincinnati as early as 1871.

(14) Alabama

The first firebrick in Alabama were produced at Bessemer in 1887 at the plant now owned by the Alabama Clay Products Company. The plant was constructed under the direction of S. P. Harbison, who later became one of the organizers of the Harbison-Walker Refractories Company. The original company was known as the Bessemer Fire Brick Company.

(15) Washington

The first firebrick were manufactured in Washington by the Denny Clay Company in 1892 in the old Denny plant at Van Asselt in South Seattle. The material used was a flint clay from Kummer, Washington.

(16) Utah

Thomas and W. L. Ellerbeck organized the Utah Fire Clay Company and constructed a plant in Salt Lake City in 1900, in which the first fire-clay brick produced in Utah were manufactured. The production of refractory assay ware was started in this plant at the same time.

VI. First Silica Refractories

(1) Ohio

J. Parke Alexander is credited with the manufacture in the United States of the first lime-bonded silica brick at the Diamond Fire Brick Company plant in Akron, Ohio, in 1880.[8] He obtained a patent on his process. Alexander established the Diamond Fire Brick Works in 1866, but his production was confined to fire-clay refractories until 1880. For his silica-brick mixture, he used Sharon conglomerate with hydrated lime as the bond.

A clay-bonded silica brick, branded Dinas Silica, was manufactured by J. R. Thomas of the Niles Fire Brick Company, Niles, Ohio,[8] in the early 1880's. This Company was established in 1872 for the production of fire-clay brick, and the clay-bonded silica brick were the first of this type to be made in this country.

(2) Pennsylvania

According to Kurtz,[9] the first silica brick produced in Pennsylvania were made by A. J. Haws and Son at Johnstown in 1884. The ganister for these brick was shipped from McKee's Gap, Blair County, Pennsylvania, by Jesse L. Hartman of Hollidaysburg. In 1886, Hartman shipped fifty-six tons of ganister from the same quarry to the Star Fire Brick Works from which the first silica brick made by this Company were produced; this plant was taken over later by the Harbison-Walker Refractories Company.

In 1899, W. H. Haws of Johnstown built the first plant exclusively for the manufacture of silica brick. In 1901, the Mount Union Silica Brick Company built a plant in that now famous center of manufacture; this plant was later absorbed by the Harbison-Walker Company. This was followed by plants at Alexandria, Sproul, and other points in Pennsylvania.

A distinct advance was made in the manufacture of silica brick with the installation of the first Norton silica-brick machine at the Mount Union Refractories Company plant at Mount Union in 1920. This machine drops slugs of silica "mud" into molds from an overhead tank; the excess is cut off, the brick are "slicked," and the mold is dumped mechanically on to pallets.

(3) Montana

Silica brick were first made in Montana at Anaconda in 1885 at the refractories plant of the Anaconda Copper Company[10]; the original process is still in use. The mix, made wetter than usual, is molded in wood or steel molds, and the brick are dumped on pallets. As soon as they take a slight "set," they are run through a special heavy-duty power repress. When they are pressed, they contain sufficient water to bring some of the lime and colloidal silica to the surface, which gives the fired product a dense, glassy skin. The brick weigh from 2 to 4 ounces more than hand-molded brick.[11]

(4) Colorado

Colorado entered the silica-brick field in 1902 when the Standard Fire Brick Company of Pueblo started production. The Diamond Fire Brick Company at Canon City began manufacture in 1910.

(5) Illinois

The Baraboo quartzite of the Devil's Lake region of Wisconsin, which supplies the silica-brick plants of the Chicago district, was first used at a plant erected and operated under the firm name of the American Refractories Company, at Joliet, Illinois, in 1906, by E. M. Allen, W. F. McCook, and Emil Winter. Plants were erected later at Joliet and East Chicago by the General Refractories Company and the Harbison-Walker Refractories Company, respectively, to use the same material.

(6) Utah

The first production of silica brick in Utah was at the Western Fire Clay Company plant in Salt Lake City in 1908 under the direction of A. F. Greaves-Walker. One of the processes used was that which has been described as the "Anaconda method,"[11] in which the slop-molded brick were run through a power repress as soon as they took an initial "set."

Silica brick were also made by the dry-press process. This was the first successful use of this process in the manufacture of silica brick in this country.

(7) Alabama

Alabama entered the silica-brick field in 1909 when the first brick were produced at the Birmingham silica-brick plant of the Harbison-Walker Refractories Company.

(8) California

The manufacture of silica brick in California began in 1918 at the plant of the Atlas Fire Brick Company in Los Angeles. The first efforts were not very successful, but with the discovery of a quartzite deposit in San Bernardino County in 1924, an excellent product was developed.

VII. First Magnesite Refractories

The first magnesite refractories were produced in this country during the lifetime of the present generation of manufacturers. They were made by the Fayette Manufacturing Company at Layton, Pennsylvania, in 1895. The principals in this company were W. A. Stanton and J. G. Wainwright of Pittsburgh and Frank Williams of Johnstown.[12] The material used was a mixture of Austrian and Grecian magnesites, the latter being a by-product of the manufacture of carbonic acid gas. The brick were slop-molded.

The first unfired magnesite refractories were produced in 1913 at the Chester (Pa.) plant of the Harbison-Walker Refractories Company.[13] These were known as "Metalkase" brick, the ground magnesite being tamped into rectangular sheet-steel containers with open ends.

In 1928, unfired magnesite refractories were first produced commercially by the dry-press process at the plant of the General Refractories Company, Baltimore, Maryland.[14]

One of the most important advances in the manufacture of magnesite refractories took place in 1916 when the Harbison-Walker Refractories Company first made magnesite brick by the dry-press process.

VIII. First Chrome Refractories

According to McDowell and Robertson,[15] the first chrome refractories were made about 1896 at the old 22nd Street Works in Pittsburgh (later absorbed by the Harbison-Walker Refractories Co.).

In 1899, the Fayette Manufacturing Company began manufacturing at Layton, Pennsylvania, under the direc-

tion of E. M. Allen and Frank Williams.[12] Production was later transferred to a new plant at Chester, Pennsylvania, which eventually became the Chester plant of the Harbison-Walker Refractories Company. Turkish ore was used.

The first commercial unfired chrome refractories were produced at the plant of the General Refractories Company at Baltimore in 1933. In this refractory, magnesite is added to the ground chrome ore.

IX. High Alumina and Alumina Refractories

The first successful attempt to use bauxite in refractories was made by the Laclede-Christy Fire Clay Company of St. Louis, Missouri, in 1906. The product was cement kiln liners. Although the product was successful from the standpoint of service, the difficulties encountered in bonding and high-firing shrinkage discouraged the extensive use of the material.

In 1908, W. G. Hipp of the Massillon Stone and Fire Brick Company, Massillon, Ohio, first used Missouri diaspore for the manufacture of refractories. He obtained the material from a deposit just north of Rolla, Missouri.[16] Diaspore was used by this Company to manufacture high-temperature crucibles and special high-temperature refractory brick and shapes.

A distinctly new development in the high alumina field was the establishment in 1928 by the Corhart Refractories Company at Louisville, Kentucky, of a plant to manufacture glass-tank refractories from material fused in the electric furnace and cast in molds while molten. The basis of the mixture used is diaspore. The experimental work in "electrocast" refractories was carried on at the Corning Glass Works, Corning, N. Y. This work, which began in 1921, was continued until production began at Louisville.

Refractories of fused alumina were first produced by the Norton Company at Worcester, Massachusetts, in 1910[17]; the products were small articles for high-temperature laboratory furnaces; this was followed by a gradual expansion into a line of brick and shapes for large commercial installations.

Although the Corhart Company was the first to fabricate refractories from an electrically fused mixture, artificial refractory materials, such as silicon carbide and fused alumina, had been produced previously on a large scale; other synthetic refractories, such as sillimanite and spinel, had also been produced on a small scale. The first commercial production of electric-furnace sillimanite, mullite, and spinel occurred in Los Angeles in 1920 at the plant of the Vitrefrax Company. The development of the process and materials was under the direction of Thomas S. Curtis.

X. Silicon Carbide Refractories

The first commercial silicon carbide refractories were produced by the Carborundum Company in 1897, although Acheson had experimented with this material before 1892 when his first patent was issued. The first refractories were clay bonded, and the electrically fused product was developed later.

XI. First Zirconia and Zircon Refractories

Zirconia refractories were first produced by the Foote Mineral Company of Philadelphia, Pennsylvania, in 1914 under the direction of H. C. Meyer.[18] The first brick were made by the slop-mold method, but the dry-press process was developed later by A. F. Greaves-Walker at the Baltimore plant of the American Refractories Company. The product was sold under the trade name, Zirkite. The ore was shipped from the Caldas region of southern Brazil.

Although zircon refractories have not been produced commercially in the United States, experimental products were made by the American Refractories Company at Baltimore in 1920 under the direction of A. F. Greaves-Walker. Experimental products were produced later in a pilot plant at Niagara Falls, New York, by the Titanium Alloy Manufacturing Company.[19] The zircon grain used in the original experiments was from Florida.

XII. First Forsterite Refractories

The latest development in the super-refractories field was the production of forsterite brick in 1933 by the Harbison-Walker Refractories Company under the direction of F. A. Harvey and R. E. Birch.[13] The first brick, made at Hays Station, Pennsylvania, contained olivine mined in North Carolina, to which sufficient magnesite was added to form the forsterite. The product is slightly basic.

XIII. A New Era in the Industry

The beginning of the twentieth century marked a new era in the refractories industry. After the long depression preceding the election of President William McKinley (1896), which left a number of the refractories companies in a weak financial condition, a group of leaders appeared, who within the next ten years laid the foundation of the strong and progressive industry that exists at present. Included in this group were S. P. Harbison, S. C. and Wm. Walker, H. W. Croft, and Hamilton Stewart, who organized the Harbison-Walker Refractories Company in 1902; Emil Winter, W. F. McCook, and E. M. Allen, who organized the American Refractories Company in 1906; and E. S. Hitchins and W. A. Stanton, who organized the General Refractories Company in 1911.

At a considerably later date, 1929, a third consolidation took place when the North American Refractories Company was organized. This consolidation was promoted by Blair and Company of New York City and brought together such well-known refractories men as J. D. Ramsay, E. M. Weinfurtner, H. E. Stuhler, J. M. McKinley, J. H. Cavender, E. H. Gartrell, H. S. Sleicher, and T. N. Kurtz.

The Harbison-Walker Refractories Company grew rapidly from the beginning and now operates twenty-two plants in the east, middle west, and south.

The General Refractories Company expanded less rapidly, but it absorbed the plants of the American Refractories Company in 1923, and it now operates twenty plants in the same sections.

The North American Refractories Company originally consisted of fifteen plants; later, it took over three other companies in Pennsylvania, Ohio, Kentucky, and Missouri.

The two first-named organizations immediately brought about improvements in processes and quality. It was during this period that the first technically trained men were

brought into the industry, and the first attempts were made at technical control of materials and products. Research in refractories also began at this time.

XIV. First Refractories Engineers

The first engineer to enter the refractories industry as such was E. M. Allen, who was employed in 1899 by the Fayette Manufacturing Company at Layton, Pennsylvania. He was a mechanical engineer formerly employed in the steel industry.

Other pioneers in refractories engineering were Kenneth Seaver, a civil engineer, employed in 1902 by the Harbison-Walker Refractories Company; A. F. Greaves-Walker, a ceramic engineer, employed in 1904 by the Olive Hill Fire Brick Company, Olive Hill, Kentucky; and A. J. Aubrey, also a ceramic engineer, who went to St. Louis with the Laclede Fire Brick Company at the same time. Under the direction of Greaves-Walker and Aubrey, the first control and research laboratories in the industry were established. Allen received his training at Purdue University, and Seaver was trained at the Massachusetts Institute of Technology. Greaves-Walker and Aubrey were among the early students registered in the department of ceramic engineering established only a few years before by the late Dr. Edward Orton, Jr., at Ohio State University. Their employment was the first recognition of this new branch of engineering by the refractories industry.

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UNIVERSITY OF NORTH CAROLINA, RALEIGH UNIT
RALEIGH, NORTH CAROLINA

ACTIVITIES OF THE SOCIETY

REPORT OF THE COMMITTEE ON STANDARDS

This report of the Committee on Standards of The American Ceramic Society is a compilation of the several reports of representatives of The Society to various organizations dealing with standards, specifications, and methods of testing. It is compiled so that members of The Society may learn of the work that has been accomplished by these organizations on which The Society is represented. In cases where the member is interested in learning more details of definite work, he is referred to the publications of these organizations or to the representative of The American Ceramic Society on that organization.

American Foundrymen's Association

L. C. HEWITT (*Chairman*), Laclede-Christy Clay Products Co., St. Louis, Mo.: A meeting of the Joint Committee on Foundry Refractories was held in Chicago on May 7, 1940. The American Foundrymen's Association has formed a special committee to prepare a handbook on cupola practice, and the Joint Committee has agreed on an outline for a chapter on cupola refractories. Cooperation is being extended by the Joint Committee in the preparation of the manuscript.

American Society of Mechanical Engineers

Petroleum Division, H. R. STRAIGHT (*Chairman*), Straight Engineering Co., Adel, Iowa: No Report.

Process Division, W. KEITH MCAFEE (*Chairman*), Universal Sanitary Mfg. Co., New Castle, Pa.: There has been no standards activity in the ceramic field.

International Chemical Congress

ALEXANDER SILVERMAN (*Chairman*), University of Pittsburgh, Pittsburgh, Pa.: The International Union of Chemistry has not functioned since the beginning of the World War II, so that there is nothing to report concerning its activities during the past year.

National Research Council

Division of Chemistry and Chemical Technology, ALEXANDER SILVERMAN (*Chairman*): This organization is interested in gathering data for pure substances. These may prove important in helping those who are trying to establish standards for ceramic materials. (For complete Report, see p. 220, this issue.)

Division of Geology and Geography, R. B. SOSMAN (*Chairman*), United States Steel Corp., Kearny, N. J.: This Report will be published later.

International Association for Testing Materials

S. M. PHELPS (*Chairman*), Mellon Institute, Pittsburgh, Pa.: There has been no activity in the field of refractories.

International Commission on Glass

J. C. HOSTETTER (*Chairman*), Hartford-Empire Co., Hartford, Conn.: For Report, see *The Bulletin*, p. 176, May, 1941.

Inter-Society Color Council

WOLDEMAR WEYL (*Chairman*), Pennsylvania State College, State College, Pa.: The Delegation of The American Ceramic Society to the Inter-Society Color Council has been interested in the attempt of the Council to find what terms are used in talking about colors. As

noted in the January, 1941, issue of *The Bulletin*, p. 37, the members of The American Ceramic Society have been asked by the Delegation to send a list of terms and their meanings to Mr. Hunter, National Bureau of Standards, Washington, D. C., a member of the Delegation. Color terms rather than color names, e.g., such terms as strong, deep, hue, etc., are being sought in the field of ceramics.

In collaboration with the Color Council, especially with Deane B. Judd, Mr. Hunter, and Campbell Robertson and the President of The American Ceramic Society, a Symposium on Color was organized for the Meeting of The American Ceramic Society in Baltimore, Monday, March 31 (these papers will be published later in *The Journal* or *The Bulletin* of The Society). A Summary on Color Terms will also be published.

The Chairman of the Delegation represented The American Ceramic Society at other meetings where various color problems were discussed and the aims of the Inter-Society Color Council were displayed by the reports of its different energetic committees.

American Society for Testing Materials

Committee A–1 on Steel, H. F. STALEY (*Chairman*), Metal and Thermit Corp., New York, N. Y.: Nothing has been accomplished during the past year of interest to the members of The American Ceramic Society.

Committee C–8 on Refractories, HEWITT WILSON (*Chairman*), Bureau of Mines, Norris, Tenn.: For this Report, see the April, 1941, issue of *The Bulletin*, p. 139.

Committee C–11 on Gypsum, R. F. GELLER (*Chairman*), National Bureau of Standards, Washington, D. C.: This Committee has taken up no subjects of interest to The American Ceramic Society, nor is any work contemplated. The secretaries of the Vitrified Chinaware Manufacturers Association and of the U. S. Potters Association were requested three years ago to state whether there were any questions in connection with pottery plaster to be brought before this Committee. To date, no reply has been received, from which it may be assumed that the potters are entirely satisfied with the plaster which is now being supplied to them.

Committee C–14 on Glass and Glass Products, G. W. MOREY (*Chairman*), Geophysical Laboratory, Washington, D. C.: For this Report, see the April, 1941, issue of *The Bulletin*, p. 139. In addition, the following report on activities of this Committee includes five tentative standards that are not on the published list:

C146–39T Chemical Analysis of Glass Sand.

C147–40T Hydrostatic Pressure Test on Glass Containers.

C148–40T Polariscopic Examination of Glass Containers.

C149–40T Thermal Shock Test on Glass Containers.

C158–40T Flexure Testing of Glass.

The methods on Hydrostatic Pressure, Polariscopic Examination, and Thermal Shock of Glass Containers have been modified this year.

The tentative standard on Flexure Testing of Glass is new.

Committee C–15 on Manufactured Masonry Units, R. L. CLARE (*Chairman*), Federal Seaboard Terra Cotta Co., South Amboy, N. J.: For this Report see the April, 1941, issue of *The Bulletin*, p. 138.

Committee D–3 on Gaseous Fuels, C. H. PARMELEE (*Chairman*), Onondaga Pottery Co., Syracuse, N. Y.: The representative of The American Ceramic Society attended a meeting of this Committee in Atlantic City on October 10, 1940. There was a meeting of the entire Committee as well as several subcommittees, and substantial progress has been made on a number of phases of this work. Arrangements were made for a spring meeting to be held in Washington at which time it was thought some of the subcommittee work could be reported to the main Committee for approval or rejection. This spring meeting was held in Washington, D. C., on March 3. A report of the year's activities will be made at a later date.

Committee D–9 on Electrical Insulating Materials, L. E. BARRINGER (*Chairman*), General Electric Co., Schenectady, N. Y.: The activities are summarized as follows: (*a*) A change was made in the water-absorption test method for porcelain (A.S.T.M. D116) to permit testing of smaller test specimens. (*b*) Methods of testing steatite bodies are under study. (*c*) Minor changes were made in the testing procedure for lime glass insulators, D468; a testing program is being planned to obtain additional data on glass insulators. (*d*) The Committee is cooperating with committees of other technical societies regarding gauging and other matters relating to testing glass insulators. (*e*) Methods relating to the determination of power factor and dielectric constant have been under study; it is tentatively planned to have papers on this subject presented at the next Annual Meeting of The Society. (*f*) Fundamental studies of the dielectric strength of glass are being continued. The test methods for porcelain and glass insulators prepared by Committee D–9 and published by A.S.T.M. are as follows: D116–39, Standard Methods of Testing Electrical Porcelain; D468–39T, Tentative Methods of Testing Pin-Type, Lime Glass Insulators; and D550–39T, Tentative Methods of Testing Glass Spool Insulators.

American Standards Association

Sectional Committee on Minimum Requirements for Plumbing and Standardization of Plumbing Equipment (Project A–40), P. D. HELSER (*Chairman*), 394 S. Lexington Ave., White Plains, N. Y.: A meeting was held April 19, 1940, at the Engineering Societies Building, 29 West 39th St., New York City.

W. K. MCAFEE, *Chairman of Subcommittee No. 12 on Minimum Air Gaps in Plumbing Systems*, reported that since the last meeting of Sectional Committee A–40 held in April, 1939, Subcommittee No. 12 had prepared four drafts of the proposed American Standard for Air Gaps in Water-Distribution Systems and one draft of a proposed American Standard for Back-Flow Preventers and had held two meetings. The fourth draft of the former, with some changes and additions, was presented to the Sectional Committee for approval.

The discussion which followed centered on the matter of nomenclature and definitions as given in the proposed standards. It was finally voted and carried that the proposed American Standard for Air Gaps in Water-Distribution Systems be redrafted to include the amendments agreed on at this meeting and that copies of this revised draft be circulated to the members of Sectional Committee A–40 and to any other interested organizations or individuals who might be suggested at this meeting.

For the further information of Subcommittee No. 12, Mr. LE PAGE distributed copies of the American Standard Specifications for Drinking Fountains (Z4, 2–1935), developed under the sponsorship of the Bureau of Public Health Service of the U. S. Treasury Department.

A. M. HOUSER, *Chairman of Subcommittee No. 11 on Soldered Fittings for Tubing*, reported that this Committee had completed its work on a proposed American Standard for Soldered Joint Fittings. It was voted and carried that this proposed standard with some minor changes suggested by Mr. Houser be submitted to the members of Sectional Committee A–40 for vote on approval by letter ballot.

Mr. LE PAGE read a letter from W. C. GROENIGER, *Temporary Chairman of Subcommittee No. 1 on Minimum Requirements for Plumbing*, in which he reported that since the last meeting of the Committee, three additional organizations had agreed to cooperate in the work of this Committee and have named representatives. These are the Sanitary Brass Institute, represented by C. J. Muend; the Sanitary Cast-Iron Enameled Ware Association, represented by W. O. THOMPSON; and the Vitreous China Plumbing Fixtures Association, represented by R. H. ZINKIL.

Committee C–29 on Insulators for Electric Power Lines, D. H. ROWLAND (*Chairman*), Locke Insulator Co., Baltimore, Md.: There has been no activity during the year.

Sectional Committee on Specifications for Sieves for Testing Purposes (Project Z–23), A. S. WATTS (*Chairman*),

Ohio State University, Columbus, Ohio: This Committee was advised under date of April 5, 1940, that (1) the National Bureau of Standards has adopted the recommendation of A.S.A. Committee Z–23 as the basis for sieve testing; (2) the American Society for Testing Materials has adopted the foregoing standard under designation E11–39; and (3) revision of Federal Specifications RR–S–366 to conform to this specification is in progress.

Sectional Committee on Scientific and Engineering Symbols and Abbreviations (Project Z–10), L. E. BARRINGER (*Chairman*): A tentative draft of the Symbols List was issued in June, 1940, and approved in November. The adopted symbols are identified as a revision of Z–10c–1931.

Illuminating Society and Luminous Glassware Guild, H. H. BLAU (*Chairman*), Federal Glass Co., Columbus, Ohio: The activities of the joint committee of the Illuminating Society and Luminous Glassware Guild for the year 1940 have been confined to the work of a subcommittee on the evaluation of diffusing glasses for use with fluorescent and other tubular light sources. A preliminary report has been prepared by the Committee and published in preprint form by the Illuminating Engineering Society.

Permanent Committee on Simplification of Variety and Sizes of Vitrified Paving Brick, C. C. BLAIR (*Chairman*), Metropolitan Paving Brick Co., Canton, Ohio: Synopses of reports of the activities of this Committee have been reported from time to time in *The Bulletin of The American Ceramic Society* (see this issue, p. 228).

The Edward Orton, Jr., Ceramic Foundation

The Edward Orton, Jr., Ceramic Foundation, 1445 Summit Street, Columbus, Ohio: Research work has been established at various schools as follows: (1) New York State College of Ceramics, EVERETT THOMAS on "Effect of Glaze Penetration on Resistance of Porous Bodies to Crazing and Shivering"; (2) Ohio State University, CHARLES B. TAUBER on "Flux Constituent of Vitreous Whiteware Bodies, II"; (3) Pennsylvania State College, LANE MITCHELL, "Mineralogical and Colloidal Constitution of Certain Clay Types"; (4) Rutgers University, WILLIAM L. PESKIN, "Effect of Atmosphere on Qualities of Colors Produced in Colored Glazes of Several Types"; and (5) University of Illinois, HAROLD C. JOHNSON, "Glaze Slip Control (continuation)."

Recommendations

The Committee on Standards of The Society urges greater cooperation of the Divisions with the work of this Committee. Many standards and specifications of interest to members of The American Ceramic Society were compiled and published in the June issue of *The Journal of The American Ceramic Society* in 1928. This Committee recommends that a similar compilation be made by the representatives of the various divisions so that The Society may have an up-to-date source of these standards.

—JOHN W. WHITTEMORE, *Chairman*,
Virginia Polytechnic Institute, Blacksburg, Va.

COMMITTEE ON CHEMICAL DATA FOR CERAMISTS—PROGRESS REPORT

Division of Chemistry and Chemical Technology
National Research Council

A Committee on Chemical Data for Ceramists was appointed in December, 1939, by Chairman Herbert R. Moody of the Division of Chemistry and Chemical Technology of the National Research Council. The reasons for creating the Committee were (1) the lack of physical constants for many chemical substances important to ceramics; (2) the lack of accord for physical constants already published in handbooks and other tables; and (3) the desirability of stimulating research to correct existing data and to determine constants not yet known.

The first search was undertaken without remuneration by an assistant of the Chairman. Although the consequent report (April 6, 1940) covered almost 100 substances, it was so limited in its scope that the National Research Council realized the importance of engaging a paid library worker. The Chairman, therefore, was authorized to raise $2000 for a librarian, part-time clerical help, mimeographing, and postage.

Through funds collected after a first appeal to the glass and ceramic manufacturers, a total of $925 was established. The receipts from the first solicitation have been utilized for the library service of Kuan-Han Sun at $75.00 per month and stenographic service, $60.00. This fund will be exhausted by June 1, 1941, and a second letter of solicitation is being circulated among the manufacturers.

To obtain data for chemical elements and their compounds which are useful to ceramic and glass manufacture and to research workers, the literature up to 1933 has been covered almost completely. Little remains to be investigated to that date.

The search for literature after 1933 has been confined to *Chemical Abstracts*. Formula and subject indexes have been covered line for line to insure the inclusion of pertinent information. This work for 1934 and 1935 has been completed, although some of the original papers for 1935 have not yet been read. All significant papers are read in their entirety by Dr. Sun. For publications not available in Pittsburgh, memoranda are being accumulated, and it may be necessary to send Dr. Sun to Washington and possibly to New York. This will not be done until a sufficient list is available to justify such trips.

It is hoped that this work will be complete by the time the subject index for *Chemical Abstracts* for 1941 appears, namely, in February, 1942.

The sections being covered in *Chemical Abstracts* are No. 2, general and physical chemistry; No. 6, inorganic chemistry; No. 8, mineralogical and geological chemistry; No. 19, glass, etc.; and No. 20, cement, etc.

Ceramic Abstracts of The American Ceramic Society is also being reviewed.

Not all published data are reliable; by the time all of the information is available, however, the Committee, on the basis of the reputation of investigators and the accuracy of methods, should be able to decide what is dependable and what should be discarded. The method of procedure was indicated in the report of November, 1940. The chlorides were not included, but the increasing tendency to use chlorides for the removal of iron in glass melts suggests the addition of data concerning metal chlorides. All significant metal chlorides will be included.

Dr. Sun's task is time-consuming; thus far, more than 1300 elements and compounds are listed.

The melting point of platinum, generally used as a basis for temperature calibration between 1600° and 1900°C., was accepted as 1755°C. prior to 1930. A recent determination by Roeser, Caldwell, and Wensel of the National Bureau of Standards was 1773.5°C. The melting points of nickel, palladium, rhodium, and iridium have also been revised. As these data serve as fixed points in the high-temperature scale, a correction might be made for all of the temperature values recorded prior to 1930 or even since. There is considerable confusion in the literature relating to high-temperature data. To convert every old reading to the new value would involve much additional work. This may not be justifiable, but factors will be provided for such conversions if the time is not available for the actual calculations. A further difficulty lies in the fact that some investigators do not indicate the fixed point of reference in their determinations. Discussions of temperature factors occur in articles by H. T. Wensel, *Jour. Amer. Ceram. Soc.*, **19**, 81 (1936); R. B. Sosman, *ibid.*, **16**, 54 (1933); and L. D. Morris and S. R. Scholes, *ibid.*, **18**, 359 (1935).

Wyckoff furnishes data on crystalline dimensions to 1934 in American Chemical Society Monographs No. 19 and No. 19A. Densities will be calculated for compounds whose densities are not available but whose crystalline dimensions or interplanar distances are known.

The amount of labor involved in this program is great. Whether the entire program can be completed even with a fund of $2000 is uncertain; the report must be mimeographed and submitted to research laboratories in colleges and universities, research institutes, and to the various cooperating industrialists. Many values undoubtedly will be lacking, and the Committee must stimulate research to supply these missing values. This Committee plans (1) to furnish more reliable data than have been available heretofore; (2) to furnish more extensive data; (3) to indicate important substances for which data should be determined; and (4) to convince research laboratories that certain determinations should be made.

Committee on Chemical Data for Ceramists: GEORGE W. MOREY, FREDERICK D. ROSSINI, and ALEXANDER SILVERMAN, *Chairman*.

REPORT OF RULES COMMITTEE FOR 1941

The Committee on Rules reports that no specific questions have been referred to it since the last Annual Meeting. The following Division Rules committees have each prepared a draft of new Rules for their respective Divisions: (1) Enamel Division and (2) Structural Clay Products Division. These proposed Rules were each checked against the Constitution, Bylaws, and Rules of The Society and the suggested uniform draft for Division and Class Rules and were referred back to the proper Division members of the Committee.

The present status of Rules for Classes and Divisions stands as follows:

Rules have been adopted consistent with the present Constitution by the following Classes and Divisions: (1) Classes, (*a*) the Institute of Ceramic Engineers and (*b*) the Ceramic Educational Council; (2) Divisions, (*a*) Materials and Equipment, (*b*) White Wares, (*c*) Refractories, and (*d*) Glass.

The following Divisions have prepared proposed Rules consistent with the present Constitution but have not yet formally ratified them: (1) Enamel and (2) Structural Clay Products.

The Rules Committee has no record of any attempt as yet to bring the Rules of the Art Division into harmony with the present Constitution.

A resolution was published in the June, 1940, *Bulletin*, p. 235, in regard to the discontinuance of the Terra Cotta Division. This resolution presumably was an expression to the Board of Trustees, and we respectfully suggest that if you concur in the advisability of discontinuing this Division you should proceed to amend Article BX, Section (1) (*a*), of the Bylaws by striking out the words "Terra Cotta Division." If it is your wish to take this action, it may be accomplished by letter ballot thirty days after the forthcoming Board meeting in Baltimore, providing a motion is passed to that effect. This would then comply with the thirty-day notice requirement of Article XIV of the Constitution.

A collection of all available Rules of Local Sections and Student Branches has been made in connection with a suggestion of the Committee on Sections and Divisions that a set of uniform rules be developed. We suggest that you instruct the Rules Committee next year to prepare such a set of proposed uniform rules for Local Sections and for Student Branches. This will simplify still further the work of the officers of The Society and tend to give a better organization of these important groups of our membership.

Committee on Rules: W. KEITH MCAFEE, *Chairman;* THEODORE LENCHNER, Art Division; G. H. SPENCER-STRONG, Enamel Division; A. N. FINN, Glass Division; J. E. EAGLE, Materials and Equipment Division; R. B. SOSMAN, Refractories Division; G. H. DUNCOMBE, JR., Structural Clay Products Division; K. E. STETTINIUS, White Wares Division; M. F. BEECHER, Institute of Ceramic Engineers; and S. R. SCHOLES, Ceramic Educational Council.

(1941)

MINUTES OF THE MEETING OF THE FELLOWS

The Annual Meeting of the Fellows of The American Ceramic Society was held at the Lord Baltimore Hotel on March 30 at 7:30 P.M., Dean Edward Schramm presiding.

M. E. Holmes gave the report of the Committee for Honorary Membership which nominated Albert V. Bleininger as Honorary Member; it was moved and carried that the report of the Committee be accepted.

It was moved and carried that W. Keith McAfee as Chairman of the Committee on the History of Ceramic Education be empowered to select additional members for this Committee.

The status of the plaque to be erected in Orton Hall, Ohio State University, to commemorate the founding of ceramic education in the United States was discussed by G. A. Bole. Arthur Baggs exhibited the design of the plaque which is to be executed in terra cotta.

It was moved by J. L. Carruthers and seconded by R. C. Purdy that the officers of the Fellows shall act as a committee to investigate the possible activities that the Fellowship might undertake as a definite program; carried.

It was moved by R. B. Sosman and seconded by J. L. Carruthers that the Trustees be asked to commit to the Fellowship the duties (1) of nominating the technological committees of The Society, (2) of receiving the reports of these committees, and (3) of recommending to the Trustees any action resulting from the reports that involves the expenditure of the funds of The Society; carried.

It was moved by R. B. Sosman and seconded by G. A. Bole that Article II, Section 5, of the Rules of the Fellows be amended to the effect that the incoming Dean is elected for three years, the Associate Dean for two years, and the Secretary-Treasurer for one year, and after the terms expire, the officers are to be elected for three years; carried.

It was moved by Edward Schramm and seconded by J. L. Carruthers that the Dean be authorized, if he so desire, to delegate to the Associate Dean the task of handling applications for Fellowship; carried.

It was moved by J. L. Carruthers and seconded by Douglas Stevens that the rules of the Fellowship be waived to permit the elevation of twenty-eight members to Fellowship; carried.

Dean Schramm announced the election of the following as officers of the Fellowship: *Dean*, R. B. SOSMAN; *Associate Dean*, T. N. MCVAY; and *Secretary-Treasurer*, HERBERT INSLEY.

—T. N. MCVAY, *Secretary-Treasurer*

AUTUMN MEETING SCHEDULES

Art: Blue Ridge, N. C., August 1–2

Enamel: Porcelain Enamel Institute Forum, Ohio State University, October 8–10

Glass: Conneaut Lake, Ohio, September 12–13

Materials and Equipment and White Wares: Summit Hotel, Uniontown, Pa., September 19–20

Refractories: Granville Inn, Granville, Ohio, September 5–6

Structural Clay Products with Structural Clay Products Institute: To be announced

Forty-Fourth Annual Meeting
Cincinnati, Ohio
April 19–25, 1942

A REAL SELLING CHALLENGE

A Net Loss of 163 Personal and 15 Corporations by "Cut-Offs" April 1, 1941

A Gain of 60 Members over the Record of April 1, 1940, Does Not Compensate This Loss.

New Members since April 1 Total 40 Personal and 1 Corporation. Renewals Total 26 Personal and 2 Corporations.

Of Real Concern Is the Failure of 203 Persons and 16 Corporations to Renew Memberships.

53 of These Persons and 14 Corporations are located in Countries at War.

Keeping Members Sold Is a Companion Problem to Selling The Society to More Members

PAID MEMBERSHIP RECORD

Date of Record	Members Paid Personal	Members Paid Corporation	Deferred	Subscriptions	Monthly Sales	Total Circulation
December 20, 1940	1995	260	25	574	220	3074
January 20, 1941	2007	262	27	594	220	3110
March 10, 1941	2023	257	26	620	220	3146
April 21, 1941	1794	247	47	563	220	2871
May 19, 1941	1839	249	47	580	220	2935
May 21, 1940	1801	247	27	552	220	2847
Gain	38	2	20	28		88

NEW MEMBERS FOR MAY

Corporation

CERAMICS PUBLISHING CO., INC., LeRoy W. Allison (voter), 421 Parker St., Newark, N. J. (formerly in name of LeRoy W. Allison, personal member).

FERRO ENAMELS (AUSTRALIA) PTY. LTD., R. M. Mueller (voter), Bourke Rd., Alexandria, N.S.W., Australia.

Personal

ABRAMSON, ISAAC, Klabin Irmaos & Cia., Rua Buenos Ayres 4, Rio de Janeiro, Brazil; ceramic engineer.

BLENKO, W. H., Blenko Glass Co., Milton, W. Va.; owner.

CHANDLER, HARRY L., 4340 41st Street, Camden, N. J.; moldshop foreman, Universal Sanitary Mfg. Co.

COCKAYNE, W. R., Cleveland Magnesite & Refractory Co., Ltd., Normanby Brickworks, Normanby, Middlesbrough, Yorkshire, England.

LENNON, JOHN W., 603 Chestnut St., Latrobe, Pa.; Stupakoff Ceramic & Mfg. Co.

POULTON, ROBERT F., 2763 N. Congress Rd., Camden, N. J.; assistant casting shop foreman, Universal Sanitary Mfg. Co.

*PRIMM, HERBERT E., 1041 S. Fourth St., Alhambra, Calif.

RABE, N. A., 618 Haddon Ave., Collingswood, N. J.; casting shop foreman, Universal Sanitary Mfg. Co.

RANKIN, GEORGE T., Columbus Dental Mfg. Co., 634 Wager St., Columbus, Ohio.

TALLMAN, W. S., 301 Forest Ave., Chattanooga, Tenn.; potter, American Lava Corp.

WITKOWSKI, STANLEY, 60 Harding Ave., Oaklyn, N. J.; assistant sliphouse foreman, Universal Sanitary Mfg. Co

* Former member of The Society rejoining.

Student

New York State College of Ceramics: LEWIS E. SHAYLER.

MEMBERSHIP WORKERS' RECORD

Personal		Corporation	
G. W. Fichter	1	Office	2
R. O. Hummel	1	**Student**	
J. R. Kauffman	1	R. M. Campbell	1
W. K. McAfee	4		
Office	4	**Grand Total**	**14**

ROSTER CHANGES DURING MAY*

Personal

ALBERT, JOSEPH, Metter, Ga. (University, Ala.)

BALDWIN, WILLIAM J., Crane Co., Div. of Engineering & Research, 4100 S. Kedzie Ave., Chicago, Ill. (Buffalo, N. Y.)

BERGIN, WILLIAM M., Owens-Corning Fiberglas Corp., Box 880, Pawtucket, R. I. (Newark, Ohio)

COFFMAN, WILLIAM N., 610 N. Washington, Owosso, Mich. (Cadet, Mo.)

COLE, WILLIAM G., JR., Cary Hall, Box 586, Purdue Univ., Lafayette, Ind. (Cleveland, Ohio)

COLLINS, PAUL F., Austenal Laboratories, Inc., 5932 Wentworth Ave., Chicago, Ill. (Columbus, Ohio)

CRAMER, W. R., 1251 W. Princess St., York, Pa. (Pittsburgh, Pa.)

DAGER, PROBERT W., Joaquin Pottery, Stockton, Calif. (Detroit, Mich.)

DAVIES, CHESTER A., Bear Tavern Road, Titusville, N. J. (Yardley, Pa.)

FORD, WILLIAM D., 126 N. Stone Ave., La Grange, Ill. (Mt. Clemens, Mich.)

GALBRAITH, ROBERT, E. I. du Pont de Nemours & Co., R. & H. Chemicals Dept., Ceramic Div., Perth Amboy, N. J. (Cleveland, Ohio)

GRIFFITH, R. E., E. J. Lavino & Co., 1528 Walnut St., Philadelphia, Pa. (Pittsburgh, Pa.)

KNAPP, ERNEST W., New England Brick Co., 22 Beacon St., Boston, Mass. (Hamilton, Ontario, Canada)

LAIRD, CHARLES, 750 Greeley Ave., Webster Groves, Mo. (Houston, Tex.)

MCBREEN, KENNETH L., 565 11th Street, Richmond, Calif. (Seattle, Wash.)

MILLER, ROGER O., 18 W. Delaware Ave., Pennington, N. J. (Trenton, N. J.)

MUELLER, JAMES I., Group 6, ERC, Ft. Leonard Wood, Mo. (Ft. Belvoir, Va.)

NEFF, RUSSELL C., 354 Wister Road, Wynnewood, Pa. (East Palestine, Ohio)

ORTMAN, ROBERT A., Box 2538, Honolulu, Hawaii (Seattle, Wash.)

ROBINSON, GILBERT C., 770 Myrtle St., Atlanta, Ga. (Norris, Tenn.)

SCHOTTS, WALTER H., Roseville, Ohio (Crooksville, Ohio)

SCHULTZ, FRANK C., Box 387, Black Rock Mine, Bishop, Calif. (Los Angeles, Calif.)

SMALTZ, HUBERT J., Morrison, Ill. (New Lexington, Ohio)

SOLOMON, VICTOR J., 626 S. Main St., Findlay, Ohio (High Point, N. C.)

TUCKER, BRADFORD S., E. J. Lavino & Co., Lynchburg, Va. (Philadelphia, Pa.)

WEST, HOWARD F., 922 Washington St., Lockport, Ill. (Streator, Ill.)

* Address in parentheses is former address.

LOCAL SECTIONS

PITTSBURGH SECTION

The Pittsburgh Section met on May 13, 1941, at Mellon Institute. E. E. Callinan, refractories and combustion engineer with the Timken Roller Bearing Company, Canton, Ohio, spoke on "Some Refractories Problems Found in a Steel Plant."

—LOUIS A. SMITH, *Secretary*

SOUTHERN CALIFORNIA SECTION

The Southern California Section held its first regular meeting under the new officers on May 2, 1941, at Carl's Cafe. Sixty-six members attended the steak dinner.

M. E. Manson, Washington-Eljer Co., Los Angeles, gave a talk on "Pebble Mill Operation," which was followed by a general discussion.

Interesting sidelights on the business and social aspects of the Annual Meeting in Baltimore were discussed by those who attended. Among these were Gordon Stewart of the Braun Corporation and president of this Section; Joe Stevens of the Emsco Refractories Co.; Clare Chaffee of the Vitrefrax Corporation; and F. A. McCann of the Pacific Clay Products Co.

—RALPH H. MARTIN, *Secretary*

MICHIGAN-NORTHWESTERN OHIO SECTION

A meeting of the Michigan-Northwestern Ohio Section was held on March 7, 1941. After dinner, A. D. Moore of the Department of Electrical Engineering, University of Michigan, spoke on "Hobbies for a Lifetime," ably demonstrating juggling and legerdemain.

The wholehearted support of the Census of Technical Man Power program sponsored by the Engineering Society of Detroit received a unanimous vote.

The last meeting of the season was held on May 23 at the Macklin Company offices west of Jackson, Mich. A

picnic dinner was served, and baseball, tennis, horseshoes, and several sound movies provided the entertainment.

Officers for 1941–1942

Chairman: JOHN A. FOSTER, 9591 Sorrento Ave., Detroit, Mich.

Vice-Chairman: JOHN F. QUIRK, A C Spark Plug Co., Flint, Mich.

Secretary-Treasurer: ALFRED R. DECKER, Champion Spark Plug Co., Detroit, Mich.

—A. R. DECKER, *Secretary*

STUDENT BRANCHES

UNIVERSITY OF NORTH CAROLINA

The North Carolina Student Branch of The American Ceramic Society took an active part in the annual Engineers' Fair on April 18 and 19.

The Department of Ceramic Engineering made an excellent showing this year, and the exhibits, which included (1) art pottery made by the students, (2) an exhibition of ceramic products, and (3) a miniature pottery and enameling plant in operation brought favorable comment from the visitors from all over the State. A small vermiculite expanding plant, which showed the production of insulating concretes, was also on display.

Section of enameling unit at the Engineers' Fair, University of North Carolina.

At the Engineers' "Brawl," the outstanding seniors were knighted in the Order of St. Patrick. The two outstanding freshmen in the Department, Owen T. Reeves and Richard Dammann, were made companions of St. Patrick. H. H. Thomas, a senior in ceramic engineering and president of the North Carolina chapter of Keramos, was selected by the faculty committee as the outstanding student in the School of Engineering for 1940–1941. This is the second year in succession that a ceramic engineer has won this honor. H. F. Randolph, a Tau Beta Pi fellow at Ohio State University, was selected last year.

At the annual meeting of the Student Branch held on May 6, the following officers were elected for 1941–1942.

CHARLES D. TAYLOR, Cincinnati, Ohio, *President;* CLAUDE N. KIMBALL, JR., Enfield, N. C., *Vice-President;* R. J. SMITH, JR., Goldsboro, N. C., *Secretary;* JAMES E. PARTLOW, Olive Hill, Ky., *Treasurer;* ADDISON HAWLEY, Goldsboro, N. C., and MONTGOMERY STEELE, Statesville, N. C., respectively, *Member* and *Alternate of Engineers' Council.*

On Scholarship Day, the J. C. Steele Cup was awarded to H. H. Thomas, of Glenarm, Md., for the third year in succession. This cup is awarded to the upper classman with the highest average for the past year. The Moland-Drysdale cup for freshmen was awarded to E. D. Cox of Charlotte, N. C.

Six of the seniors, D. F. Cox, H. S. Gibbs, Jr., M. W. Parcel, F. A. Paschal, R. C. Stuckey, Jr., and H. H. Thomas, will receive commissions in the Army in June and expect to go into service immediately thereafter. W. A. Lambertson will go to Porto Rico as ceramic engineer for the Ceramic Company of Porto Rico. J. W. Nelley and S. L. Thomas, Jr., will become associated with the Carnegie-Illinois Steel Co., Chicago, Ill. J. R. Sevier will receive a commission as ensign in the Naval Reserve, and E. R. Todd will enter the University of Alabama as a Bureau of Mines Fellow in September.

—R. J. SMITH, JR., *Secretary*

MISSOURI SCHOOL OF MINES AND METALLURGY

The Student Branch of The American Ceramic Society at the Missouri School of Mines and Metallurgy, Rolla, Mo., on April 9 elected the following officers for 1941–1942: H. B. Bute, *President;* R. A. Smith, *Vice-President;* and L. H. Bolz, *Secretary-Treasurer.*

L. A. Kimberling, head of research, Blackmer and Post Pipe Co., St. Louis, Mo., gave a talk on the manufacture of sewer pipe at the meeting held on April 30. The methods used in drying were described as well as innovations in firing practice, namely, the Francis system of air recirculation and the method of stoker-firing the round downdraft kilns. Mr. Kimberling stated that the firing period has been cut by fifty hours and a considerable saving in fuel has been brought about by these additions to the kiln.

The ceramic students have issued Volume 1, No. 1, of *Ceramic Dry & Repressed News,* "extruded, cut, and dried." The issue is five pages of mimeographed copy with campus notes, news of the Forty-Third Annual Meeting in Baltimore, a WPA project for pottery manufactured from Missouri clays, new equipment, Student Branch activities, a manganese research program, the employment of former students, a diaspore and Lumnite cement investigation, the organization of a Pottery Club, and senior theses subjects.

UNIVERSITY OF WASHINGTON

Student activities at the University of Washington in the Ceramic Engineering Department reached a new high this spring chiefly because of the completion of theses for graduation. The enameled souvenir ash trays required many patient hours of preparation. These ash trays, on completion, are a dark blue surrounding the colored insignia of the University of Washington.

The student body was deeply disappointed to hear of the leave of absence to be taken by Carl H. Zwermann during the academic year of 1941–1942. He will be leaving this July to go into active duty in the United States Army; Dr. Zwermann is a Captain in the Officer's Reserve.

Wendell Keith will assist the students this summer in various phases of ceramics. His ceramic art classes have proved to be fascinating to the students, many of whom are Art majors.

The students received valuable practical experience in testing refractories during an interesting load test on several high-grade firebrick; the A.S.T.M. standard test was used.

The annual picnic was a "natural"; for a day, at least, swimming, boating, eating, and lots of care-free fun eliminated all thoughts of "textbook blues." The academic year of 1940–1941 ended the first week of June. All of the seniors are well lined up with positions. With the present increase in all types of industrial products, the outlook is encouraging.

—JIM MCKINNELL, *Student Secretary*

THE AMERICAN CERAMIC SOCIETY
FOR CONTINUING EDUCATION
IN CERAMICS

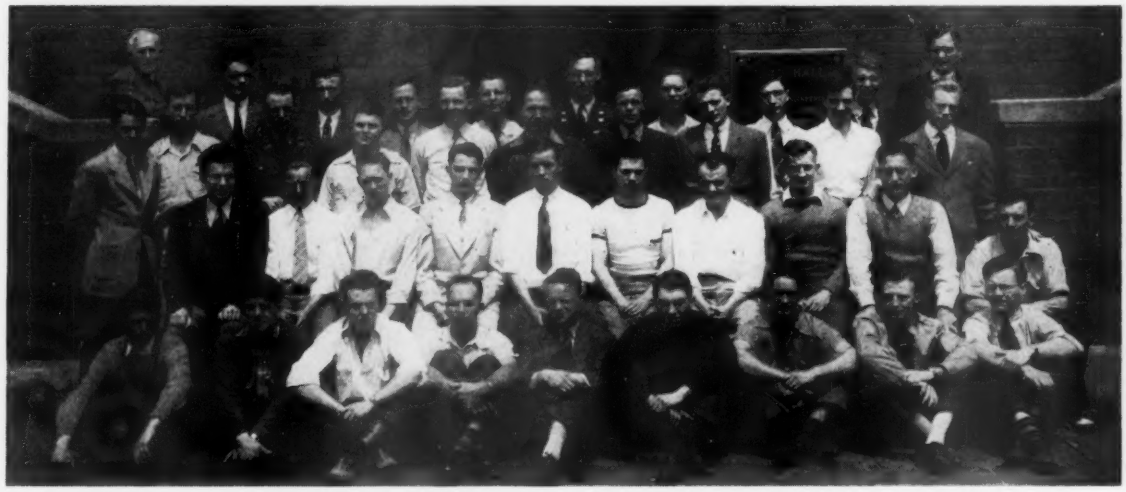
OHIO STATE UNIVERSITY

The Ohio State University Student Branch held one of its most successful meetings on April 29, 1941.

A "Board of Experts" assembled to discuss and answer questions submitted by the students on the general subject, "The Ceramic Graduate and His Place in Industry." Members of the Board were W. E. Kramer, Ceramic Products, Inc.; Fred Brownewell, Columbus Clay Products; Phil Tefft, Claycraft Co.; W. J. McCaughey, Mineralogy Department; A. R. Olpin, Engineering Expt. Station; C. E. MacQuigg, Dean, College of Engineering; and A. S. Watts, J. L. Carruthers, and R. M. King of the Department of Ceramic Engineering.

William Scharfenacher reported that the Department is soon to have a shower installed as well as a social room where it will be possible to relax between classes.

—R. H. THOMAS, *Secretary-Treasurer*



Ohio State University Student Branch of The American Ceramic Society

First row: R. H. Cowden, A. W. Witzemann, L. D. Hower, J. H. Jacobi, D. E. Postlewaite, W. J. Scharfenaker, A. M. Caito, J. T. McQuaide, R. H. Thomas.
Second row: J. O. Semmelman, A. E. Currier, W. G. Cooper, J. A. Pierce, M. M. Reuter, H. F. Russell, R. Rose, P. P. Irwin, W. H. Linkhorn, R. G. Sada, A. A. Shukle.
Third row: R. S. Esch, G. E. Brownewell, L. W. Adcock, J. H. Rickey, P. S. King, K. A. Baab, W. D. Caldwell, E. B. Snyder, D. E. Holmgren.
Fourth row: A. S. Watts, A. J. Caton, T. S. Shevlin, W. R. Patton, R. L. Reed, D. P. Frame, R. E. Hess, M. Berg, H. E. Petty, R. M. King.

PERSONAL NOTES

GEORGE H. BROWN HONORED

Twenty-Fifth Anniversary at Rutgers

A testimonial dinner was given to George H. Brown, active head of the Ceramic Department of Rutgers University on Friday evening, May 16. The dinner was held at the Carteret Club in Trenton, N. J., in commemoration of twenty-five years of service rendered by Professor Brown as director of ceramics at Rutgers. Fifty guests were present. Professor Brown was presented with a Lenox plaque bearing a reproduction of the ceramic building at Rutgers University; on the opposite side are facsimile signatures of a number of Professor Brown's friends.

LUKENS WINS DESIGN AWARD

Glenn Lukens, head of the Art Department of the University of California, was one of four persons who received Annual American Design Awards, amounting to $1000 each, given by the Lord & Taylor Co., New York, N. Y., for the outstanding achievement in design in specific fields. Mr. Lukens received the Award for the ceramic division and was credited largely for the progress of pottery manufacture in the southwest.

BUDNIKOFF ANNIVERSARY CELEBRATION

Peter P. Budnikoff celebrated his thirtieth anniversary at the Kharkov Institute of Chemical Technology on February 25, 1941. Representatives of industrial works, social organizations of the silicate industry, and scientific research institutions from Moscow, Leningrad, and other places were present. Professor Budnikoff presented a paper on "The Problem of New Cements from Local Raw Materials." G. V. Kukolev presented a paper on "Thirty Years of Scientific and Pedagogical Activities of P. P. Budnikoff." Numerous other salutatory addresses were given and congratulatory telegrams were read. The Leningrad Ceramic Scientific Research Institute presented Professor Budnikoff with a decorated vase of pink porcelain.

Professor Budnikoff is well known outside the U.S.S.R. He has published many scientific papers in the field of refractories and new kinds of cements, and he has patented twenty-nine inventions.

—E. E. STEFANOWSKY

Knowledge Is Aquired By Communication

NECROLOGY

OSCAR HOMMEL

Oscar Hommel, president and founder of the O. Hommel Company, Pittsburgh, Pennsylvania, died in Pittsburgh on Friday, April 18, following a brief illness.

Mr. Hommel was born in Fuerth, Germany, on December 9, 1868, and emigrated to this country in September, 1888. He founded the Company that bears his name in the autumn of 1891 in a small building in downtown Pittsburgh. The present factory site in Carnegie, Pennsylvania, was opened in 1909.

He was a member of the Porcelain Enamel Institute, National Association of Manufacturers, a Fellow of The American Ceramic Society, and a member of The Society since 1926.

Mr. Hommel is survived by his widow, Bella Mayer Hommel, three daughters, and one son, Ernest M., who is also connected with the Company.

Definite Purpose in Life

Mr. Hommel lived his life fully, vigorously, and with a definite purpose. He was a self-effacing man. The duties he performed and the charitable acts he consummated were not for the edification of the general public. He lived his life as he thought it should be lived, and what he achieved through his example and hard work he believed should merit no special praise. No one who knew him would question his genuine sincerity. It is not the purpose here to dwell on Mr. Hommel's deeds; he would not approve of the slightest semblance to mawkish sentimentality.

He had an indomitable courage in the face of distressing circumstances. He was less endowed, academically, than many who have failed to make the grade in such measure as he. Many bitter setbacks befell him. Through an unfortunate partnership, his firm struggled through a failure. Oscar Hommel assumed every obligation against this firm. His newly opened factory burned to the ground, a mass of twisted, charred wreckage.

The success of Oscar Hommel is not a mystery shrouded by "breaks" and good fortune; his story is prefaced by honesty and sincerity of purpose.

Oscar Hommel, 1868–1941

INSTITUTE OF CERAMIC ENGINEERS

Executive Committee

President: E. H. FRITZ, Westinghouse Electric & Mfg. Co., Derry, Pa.
Vice-President: H. M. KRANER, Bethlehem Steel Co., Bethlehem, Pa.
Secretary: H. B. DUBOIS, Consolidated Feldspar Corp., Trenton, N. J.
Past-President and Trustee Representative: H. G. WOLFRAM, Porcelain Enamel & Mfg. Co., Baltimore, Md.

MINUTES OF THE ANNUAL MEETING

The Meeting, which was held at the Lord Baltimore Hotel, Baltimore, Md., on March 31, opened at 4:15 P.M. with E. H. Fritz, Vice-President of the Institute, presiding in the absence of Mr. Wolfram who was unable to attend.

The Minutes of the last Annual Meeting were approved but not read. The Committee reports were then presented.

(1) Professional Status and Development

J. W. Whittemore, Chairman, described a paper, prepared by his Committee for the benefit of prospective ceramic engineering students (this paper was published in the February, 1941, *Bulletin*, p. 67). A. F. Greaves-Walker described a similar bulletin which he has prepared and used to good advantage for distribution to high-school students who are prospective ceramic engineering students.

M. S. Bowne inquired whether provision had been made for short courses in business administration in the curricula of the ceramic schools. He feels that there is a need for such work. Considerable discussion ensued, and it seemed to be the consensus of opinion that little time is available for such courses except as electives; in many cases, however, such courses should be taken.

(2) Committee on State Boards of Engineering Examiners

A. F. Greaves-Walker, Chairman, pointed out that it is becoming increasingly important that ceramic engineers obtain professional engineer licenses. Matters concerning reciprocity in the various states, the increasing difficulties which prevail in obtaining licenses, and the conditions existing in the Maryland State law in regard to the employment of licensed engineers were discussed. He reported that he had been advised that the last Maryland legislature had repealed the professional engineer's licensing law.

(3) Committee on Membership and Examinations

A. S. Watts, Chairman, reported that he has sixty-eight applications for consideration, and an additional 117 applications have been received as a result of a letter from Mr. Fritz to ceramic engineers who are members of the Institute.

A discussion of the need of a collection of the Constitution and Bylaws of the Institute was discussed, and Mr. McAfee pointed out that The Society has recommended strongly that such Bylaws be published both for the affiliated organizations and for The Society. Professor Greaves-Walker suggested that some of the funds of the Institute might be used for the publication of such a booklet. A suggestion was made to include the Membership of the Institute in such a bulletin and was thought to be worth while. A further suggestion was made to designate by some suitable mark Institute members as they appear in *The Bulletin of The American Ceramic Society* when the Membership Roster is published.

(4) Engineers' Council for Professional Development

This report appears on this page.

(5) Report of the Committee on Ceramic Engineering Education

E. H. Fritz, Chairman, described an activity of his Committee, wherein he solicited topics of research problems from industry for ceramic students and the schools. These subjects are being distributed to the various schools, and an effort is being made to avoid duplication in the research problems selected.

(6) Report of the Secretary

H. M. Kraner pointed out that one of the activities of the Secretary during the year is to prepare a roster of the Institute members for the Defense Planning Board.

Six men were admitted to Junior Membership, eight to Associate Membership, and eleven to Full Membership.

Attention was called to several details of the Rules which need correction and which will be taken care of later. Most of these are for the purpose of simplifying the office routine and procedure.

The financial report showed that the balance for 1940 was $1026.20, less disbursements of $93.00, or a net balance of $932.92.

Another matter discussed concerned the publication of names of men before or after their election to the Institute.

A short diseussion ensued on the proposed reduction in assessments from $2.00 to $1.00 and the matter of an activity of the Institute that would be a useful contribution to ceramics. It was suggested that a Committee be formed to look into the matter of a program of activities to be followed by the Institute.

Mr. Thiemecke described the activities of the Ceramic Engineers Club of East Liverpool, Ohio, to indicate some of the activities which a club of this kind can undertake.

The officers for the ensuing year were installed and the meeting adjourned at 6:30 P.M.

—H. M. KRANER, *Secretary*

REPORT OF COMMITTEE ON STATE BOARDS

This Committee has been active throughout the year. Several State Boards have recognized ceramic engineers and have provided for their professional licensing.

The six states added to the list since January 1, 1940, are Indiana, Nebraska, New Jersey, Pennsylvania, Texas, and South Carolina. The complete list of states which will now license ceramic engineers is as follows:

Alabama	Iowa	Oregon
Arizona	Kentucky	Pennsylvania
Colorado	Nebraska	Tennessee
Connecticut	New Jersey	Texas
Florida	New York	South Carolina
Georgia	North Carolina	Wisconsin
Indiana	Ohio	

All of the important ceramic manufacturing states are included except California, Illinois, Missouri, Virginia and West Virginia.

California licenses only structural engineers, although an effort is being made to have the legislature pass a law covering all branches of engineering.

Bills have also been presented to the legislatures of Illinois and Missouri providing for the licensing of engineers, and ceramic engineers will come under these laws in both states if the bills are passed.

After several personal conferences between the chairman of the Committee and the chairman and secretary of the State Board of Virginia, it is anticipated that ceramic engineers will receive formal recognition at the next meeting of the Board in June.

Personal conferences have been held with members of the State Board of West Virginia. The attitude of the Board members is that the ceramic engineers residing in that state have not shown any particular interest in obtaining professional licenses. The Chairman of the Committee believes that if several of the ceramic engineers residing in West Virginia would make application for licenses, the Board would then agree to grant recognition.

The Chairman of the Committee attended the annual meeting of the National Council of State Boards of Engineering Examiners held in Charleston, S. C., in October. As it is the policy of the other national engineering societies to send representatives to these meetings and to introduce these representatives at a meeting of the delegates from the various states, it is recommended that this Institute continue to send representatives to these meetings annually. It is an excellent advertisement for our branch of engineering.

The Committee is making no particular effort to obtain recognition in those states in which few if any ceramic engineers are employed. If, however, there are members of the Institute residing in such states who desire to obtain professional licenses, the Committee will be pleased to take up the matter with the State Board concerned. In every case of this kind that has been called to the attention of the Committee, it has been successful in obtaining recognition.

—A. F. GREAVES-WALKER, *Chairman*

PROFESSIONAL DEVELOPMENT

Several years ago, as president of the Institute, I attempted to convince the Engineers' Council for Professional Development that this organization was entitled to membership or at least to representation on the Council. This organization is made up of representatives of the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the National Council of State Boards of Engineering Examiners, and the Society for the Promotion of Engineering Education. This application for membership was considered at a meeting of the Council in 1938; after discussion, it was laid on the table for future consideration.

At a recent conference, Charles F. Scott of Yale University, who was president of the Council at the time our application was made, advised me to discuss the matter with Dr. Doherty of Carnegie Institute of Technology, the present president of the Council.

The suggestion was followed, and at the last meeting of the Executive Committee our application was again considered and turned down. The Committee stated that if we should be admitted to the Council, a flood of applications from other organizations would undoubtedly follow with the result that it would become unwieldy.

If is, of course, highly desirable that we have representation on the E.C.P.D., as it does not seem logical to have our accrediting program entirely in the hands of engineers of other branches. There is no harm in continuing the effort to obtain some form of representation on the Council.

—A. F. GREAVES-WALKER, *Chairman, Committee on E.C.P.D.*

NOTES AND NEWS

UNIVERSITY OF CHICAGO GEOLOGIC PROGRAMS

Fiftieth Anniversary Celebration

The geological programs in celebration of the Fiftieth Anniversary of the University of Chicago will be held under the joint sponsorship of the Geological Society of America, Section E of the American Association for the Advancement of Science, and of the University of Chicago.

The presentation of papers will be by invitation, but these will be followed by open discussion. The sessions will extend through September 25 and 26. The theme underlying the program will be "Frontiers of Knowledge in the Geologic Sciences."

The principal speaker at the sessions will be Reginald A. Daly of Harvard University whose topic will be "Glaciation and Submarine Valleys." This paper will probably be given at 4:30 P.M. on September 25.

The sessions will include four programs of one half day each as follows:

"Frontier Researches on the Structure, Properties, and Occurrence of Clay Materials and Their Practical Application" under the leadership of Ralph E. Grim, Petrographer of the Illinois Geological Survey.

"Frontier Studies of the Physical Constitution of Coal and Their Practical Significance" under the leadership of Gilbert H. Cady, Senior Geologist of the Illinois Geological Survey.

"Frontiers of Knowledge in the Field of Glacial Geology" under the leadership of Richard Foster Flint of Yale University.

"Geological Frontiers in the Search for Oil" under the leadership of A. I. Levorsen, Chairman of the Research Committee of the American Association of Petroleum Geologists.

The session on "Frontier Researches on Structure, Properties, and Occurrence of Clay Materials and Their Practical Application" will be held on September 25, 1941, at 9:00 A.M. in Room 2, Rosenwald Hall, the University of Chicago. The papers to be presented are as follows:

(1) "Modern Concepts of Clay Materials" by Ralph E. Grim, Illinois Geological Survey, Urbana, Ill.

(2) "Relation of Lattice Structure of Clay Minerals to Some Properties of Clays" by Sterling B. Hendricks, Bureau of Plant Industry, U. S. Department of Agriculture.

(3) "Applications of Modern Clay Researches in Agriculture" by Walter P. Kelley, College of Agriculture, University of California.

(4) "Applications of Modern Clay Researches in Ceramics" by F. H. Norton, Department of Metallurgy, Massachusetts Institute of Technology.

(5) Applications of Modern Clay Researches in Construction Engineering" by Hans F. Winterkorn, College of Engineering, University of Missouri.

Further details in regard to the program will be announced later. Inquiries may be addressed to Professor Edson S. Bastin, Chairman, Department of Geology, Rosenwald Hall, University of Chicago.

CENTRAL DISTRICT ENAMELERS' CLUB

A meeting of the Central District Enamelers' Club was held in Cleveland, Ohio, on May 2. About ninety visitors inspected the Ferro Enamel Corporation plant and 125 were present at the dinner. Bennett Chapple talked on "Industrial Defense" at the evening meeting.

There were more than twenty enameling plants represented; Erie, Pa., and Moundsville, W. Va., were the two "long-distance" members with fourteen members from Erie Enameling and General Electric Erie.

J. T. IRWIN, *Secretary-Treasurer*

SIXTH ANNUAL CLAY PRODUCT PLANT OPERATORS' CONFERENCE

The Sixth Annual Clay Product Plant Operators' Conference, sponsored by the Department of Ceramic Engineering and the Illinois Clay Manufacturers' Association, was held on June 6 and 7 at the Ceramics Building, University of Illinois, Urbana, Ill.

Papers and discussion were presented on the following topics: (1) The application of electrical instruments in the control of machine operations in ceramic plants; (2) the excavation of earthy materials with modern machinery, an important factor in the cost of clay products manufacture; (3) the effects of heat on the clay body and its constituents during the firing process; (4) the zinc-vapor coloration of clays; and (5) the use of chemicals of various kinds to modify the properties of clay materials and to control their behavior in forming and drying.

Following a group dinner, the annual meeting of the Illinois Clay Manufacturers' Association was held on Friday, June 6. An election of officers was held and reports of committees were presented.

PORCELAIN ENAMEL INSTITUTE FORUM

The Sixth Annual Forum of the Porcelain Enamel Institute will be held at the Ohio State University, Columbus, Ohio, October 8–10, 1941. Although the Deshler-Wallick will be the official hotel for the Forum, all meetings, except the banquet, will be held on the University campus.

ABRASIVE ASSOCIATIONS MEETINGS

The Grinding Wheel Manufacturers Association and the Abrasive Grain Association held their June meetings at the Hotel Niagara, Niagara Falls, N. Y., on June 5 and 6, respectively.

—HARRY B. LINDSAY, *Secretary-Treasurer*

VITRIFIED PAVING BRICK SIMPLIFIED PRACTICE RECOMMENDATION

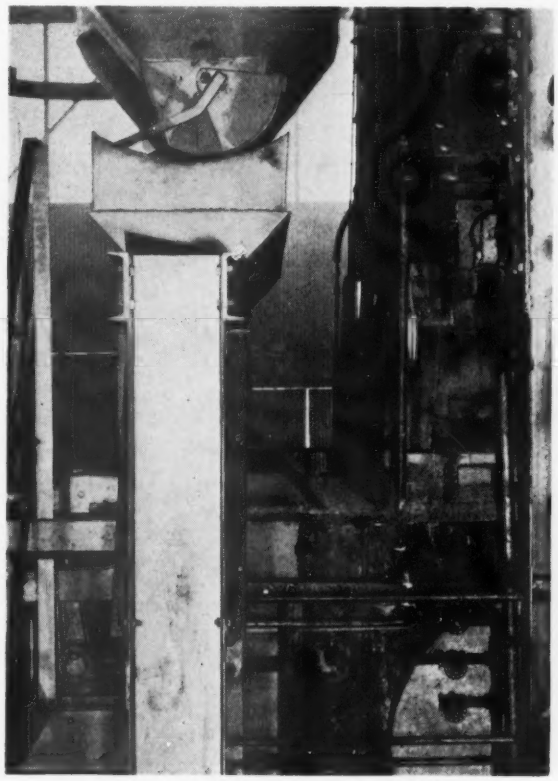
The Simplified Practice Recommendation, R1–40, Vitrified Paving Brick, has been reaffirmed without change by the Permanent Committee of the industry. The five sizes of paving brick shown in R1–40 have accounted for 85.9% of the total shipment during 1940, according to the recent survey by the Committee. Copies of R1–40 may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 5 cents each.

—EDWIN W. ELY, *Chief, Division of Simplified Practice*

NEW YORK SOCIETY OF CERAMIC ARTS

The New York Society of Ceramic Arts held its last meeting of the season on May 12 at the Architectural League, 115 East 40th St., New York, N. Y. The dinner meeting was preceded by the annual business meeting. Lawrence E. Barringer was re-elected president for 1941–1942. C. H. Vanderlaan reported a successful outcome of the recent exhibit at the National Arts Club and it was decided to hold the next exhibit in November at a gallery to be selected. In the evening, a symposium was presented on "Ceramics in Relation to Architecture" and a demonstration of public-school ceramics was given by Miss Mabel C. Brady.

Meetings of the Divisions (Autumn), Local Sections, state associations, conferences at research bureaus and universities, and the Annual Meetings of this Society offer opportunities for progress in the ceramic profession.



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The Vitro Mfg. Co.

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Gold
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Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
The Vitro Mfg. Co.

Gold Decorations
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The Hommel, O., Co., Inc.

Granulators
Lancaster Iron Works, Inc.

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Norton Co. (*Alundum-Crystolon*)

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Corhart Refractories Co.
Norton Co. (*Crystolon*)

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Norton Co.

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The Hommel, O., Co., Inc.

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Harshaw Chemical Co.

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American Rolling Mill Co.

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Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

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Ceramic Color & Chemical Mfg. Co.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
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Thomas Alabama Kaolin Co.
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Kryolith (see Cryolite)
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Lithium Minerals
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Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
The Vitro Mfg. Co.

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Foote Mineral Co.

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Hammill & Gillespie, Inc.
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The Hommel, O., Co., Inc.
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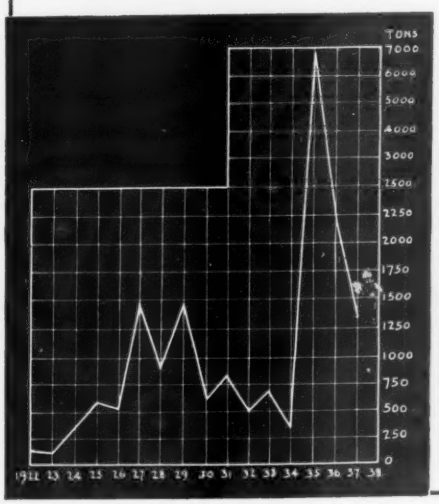

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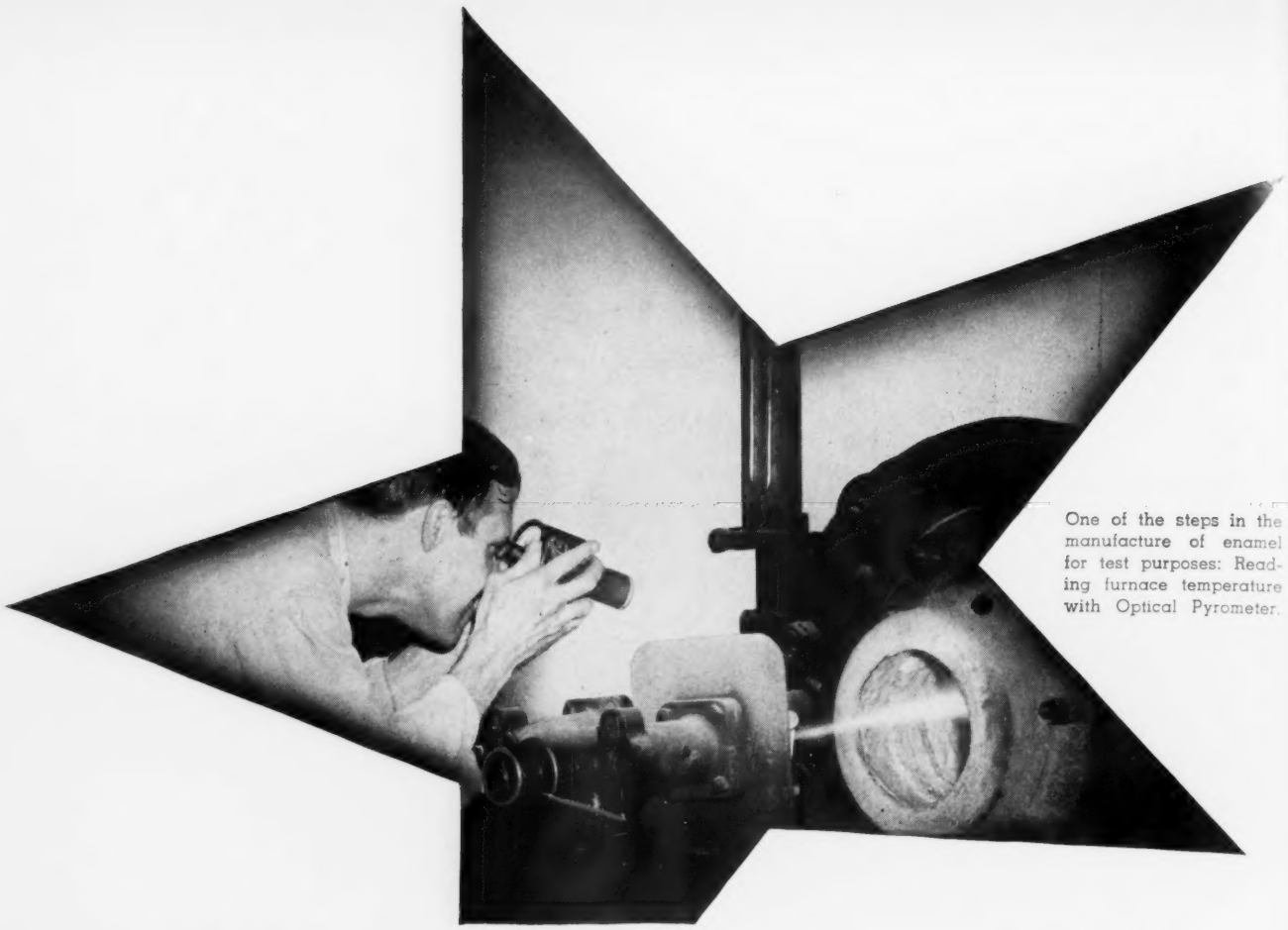

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Here, under close technical supervision, all of the steps in the manufacture are carried out—including selection and testing of raw materials, smelting, grinding, application, firing and testing. With the completion of these test runs, careful checking at given thicknesses determines reflectance, color, surface hardness and acid and alkali resistance.

Inquiries from companies with difficult enameling and glazing problems are invited.

The unusual physical and chemical properties of Metal & Thermit Tin Oxide and Sodium Antimonate assure a high degree of opacity and brilliant finish, whether white or color. Careful laboratory control at all stages guarantees the purity of these opacifiers.

M&T

TIN OXIDE
SODIUM ANTIMONATE

★

METAL & THERMIT CORPORATION

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